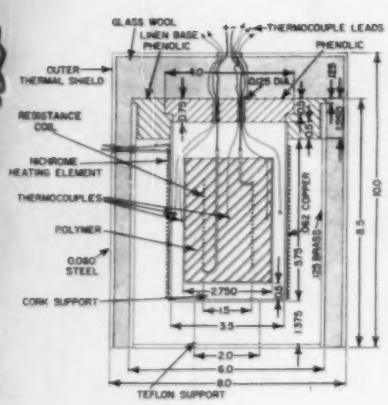
THE SOCIETY OF

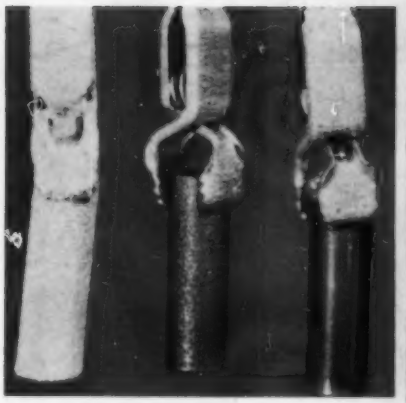
PLASTICS ENGINEERS JOURNAL

EDITORIAL DEPT.
UNIVERSITY MICROFILMS, INC.
313 N. FIRST ST.
ANN ARBOR, MICH.
14-



Cutaway drawing of calorimeter used to determine specific heat of high polymers page 1055

Land mine molded of reground glass-filled polystyrene page 1053



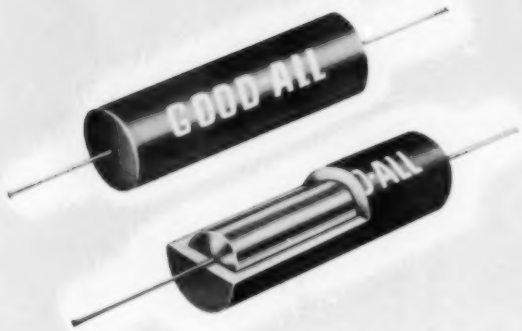
Aluminum cylinders show steps in coating by electrostatics page 1059

December 1959 • Vol. 15, No. 12

Canadian General Electric Co., Ltd.

New streamlined transformers, molded in Epon resins, have superior insulation and dielectric strength. Accuracy and over-all performance are greatly improved.

Specify Epon® Resins...



Good-All Electric Manufacturing Co.

New Epon resin-molded 600 UE capacitors have superior moisture resistance. Offer rugged, trouble-free performance because Epon resin assures high dielectric strength, low leakage.

for potting, molding, sealing, encapsulating

SWITCH TO EPON resin-based compounds for potting, molding, sealing, and encapsulating to upgrade the performance of your electrical or electronic units . . . cut costs through design simplification.

Why? Because the excellent physical properties of Epon resins eliminate the need for conventional containers and housings. Size, weight, and complexity of components are reduced.

To lower costs and speed up production, manufacturers have moved in the direction of automation. In the new mixing, metering and dispensing equipment, even the most heavily filled Epon resin formulations can be used for high-volume, rapid-curing potting, encapsulating, and sealing operations.

Epon resins can be adapted to a wide variety of formulations designed to meet your specific needs. Write now for full information including a list of suppliers of Epon resin-based formulations and manufacturers of automatic mixing, metering, and dispensing equipment.

SHELL CHEMICAL CORPORATION
50 West 50th St., New York 20, N.Y.

SHELL CHEMICAL CORPORATION
PLASTICS AND RESINS DIVISION

Central District
6054 West Touhy
Chicago 48, Illinois

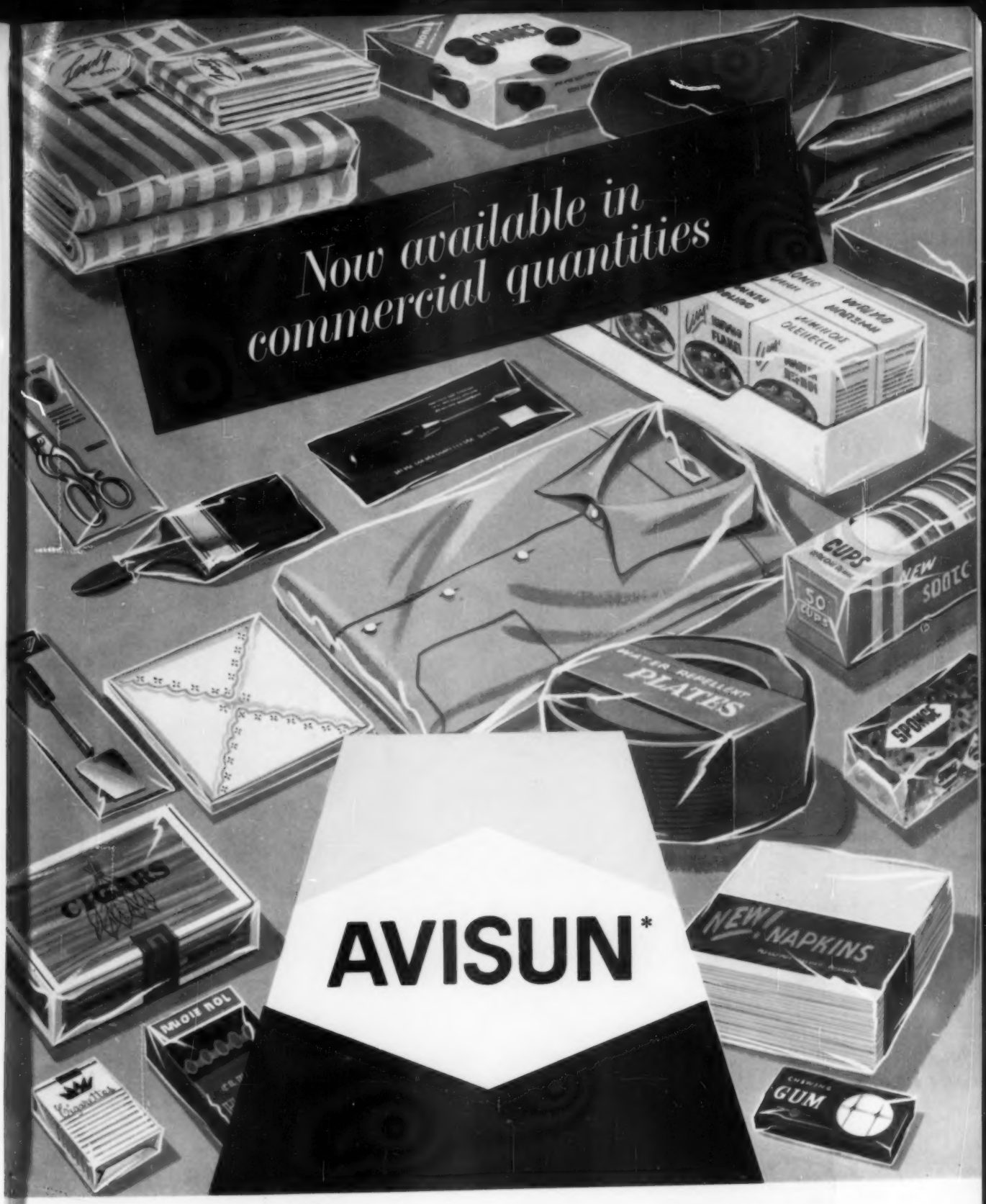
East Central District
1578 Union Commerce Bldg.
Cleveland 14, Ohio

Eastern District
50 West 50th Street
New York 20, New York

Western District
10642 Downey Avenue
Downey, California

IN CANADA: Chemical Division, Shell Oil Company of Canada, Limited, Toronto

SHELL



OLEFANE*

Polypropylene Film

*a trademark of AviSun Corp.

AviSun *OLEFANE* g

(POLYPROPYLENE FILM)

In 1 through 3 mil thickness AviSun Olefane is clear as crystal. Its gloss is sparkling . . . its "feel", warm and pleasant. Just the right flexure, too . . . neither limp nor too stiff. This adds up to instant sales appeal.

more

RESISTANCE TO GREASE AND CHEMICALS—AviSun Olefane resists attack and penetration by oil, grease, chemicals and solvents . . . ideal for liners, pouches. Excellent odor barrier, keeps flavor and aroma in—odors out.

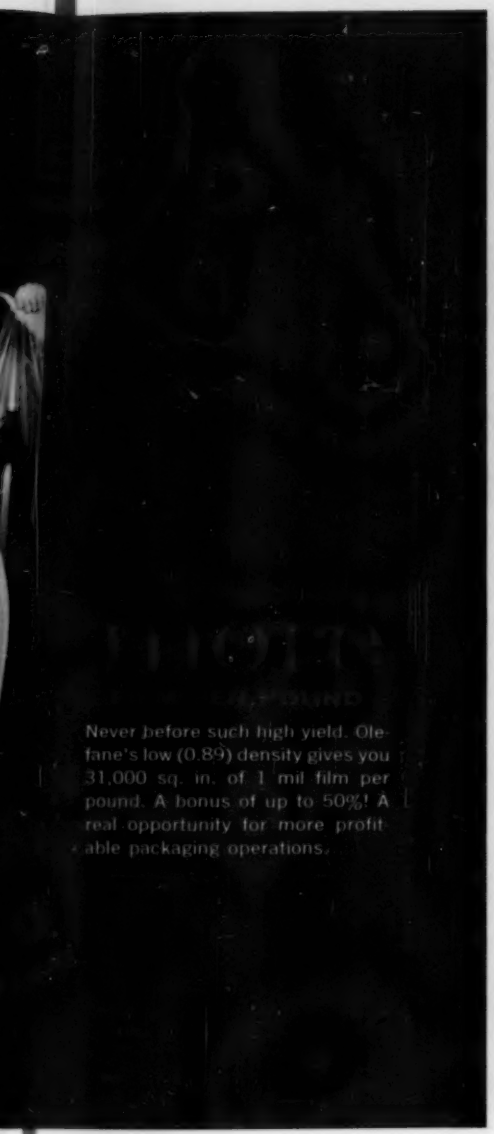
more

HEAT RESISTANCE—Olefane can be boiled . . . even sterilized at 230-250 degrees F. This extra heat resistance assures high temperature dimensional stability . . . opening many new film applications for you.

more

SHELF LIFE—Olefane is unaffected by changes in humidity . . . doesn't absorb moisture. Even after long storage under adverse atmospheric conditions, AviSun Olefane maintains its dimensions—and *does not become brittle.*

E gives you more



Never before such high yield. Olefane's low (0.89) density gives you 31,000 sq. in. of 1 mil film per pound. A bonus of up to 50%! A real opportunity for more profitable packaging operations.

AviSun Olefane resists tearing and has high tensile strength—stronger wraps from thinner gauges. Good abrasion resistance maintains high gloss and transparency . . . protects goods longer. (Conversely, the film can be made to have directional tear for easy opening when desired.)

. . . AND ITS MACHINEABILITY IS EXCELLENT

Because of its higher stiffness, Olefane performs at advantageous speeds on machines designed for other thermoplastic films. No new or rebuilt machinery needed.

AVISUN

For more information mail coupon on next page . . .

AviSun inherits a rich tradition!

AVISUN

AMERICAN VISCOSE CORPORATION

PRODUCTION KNOW-HOW—First synthetic fiber producer in America. Long experience in production of films and fibers.

CUSTOMER SERVICE—Large, complete film evaluation laboratory. Knowledge and experience in packaging machinery.

MARKETING KNOW-HOW—Many years of successful merchandising experience in the flexible packaging industry.

RESEARCH—Several years of major research specifically on Polypropylene film.

SUN OIL COMPANY

RAW MATERIALS POSITION—Low cost olefins readily available because of company ownership of oil wells, ships, pipe lines and refineries.

PROCESSING KNOW-HOW—Years of leadership in catalysis and the processing of hydrocarbons.

KNOWLEDGE OF MARKETS—Wide marketing experience in wax for wax paper, and hydrocarbons for rubber.

RESEARCH—Several years of major research on the manufacturing of Polypropylene.

Only AviSun is backed by such distinguished double resources

TECHNICAL EXPERTS AT YOUR SERVICE—Through our Customer Service Departments, the experience and know-how of both Sun Oil Company and American Viscose Corporation are available to you. AviSun Technical Specialists will gladly answer your specific questions about Olefane . . . and provide advice and assistance in planning, market research and running Olefane on your present thermoplastic film machinery. Write, wire or phone today.

CUSTOMER SERVICE • AviSun Corporation, Post Road
Telephone, HUbbard 5-1151 MARCUS HOOK, PA.

AVISUN Corporation
Post Road, Marcus Hook, Pa.

Please send me latest complete information covering Olefane Polypropylene film.

NAME _____

COMPANY _____ POSITION _____

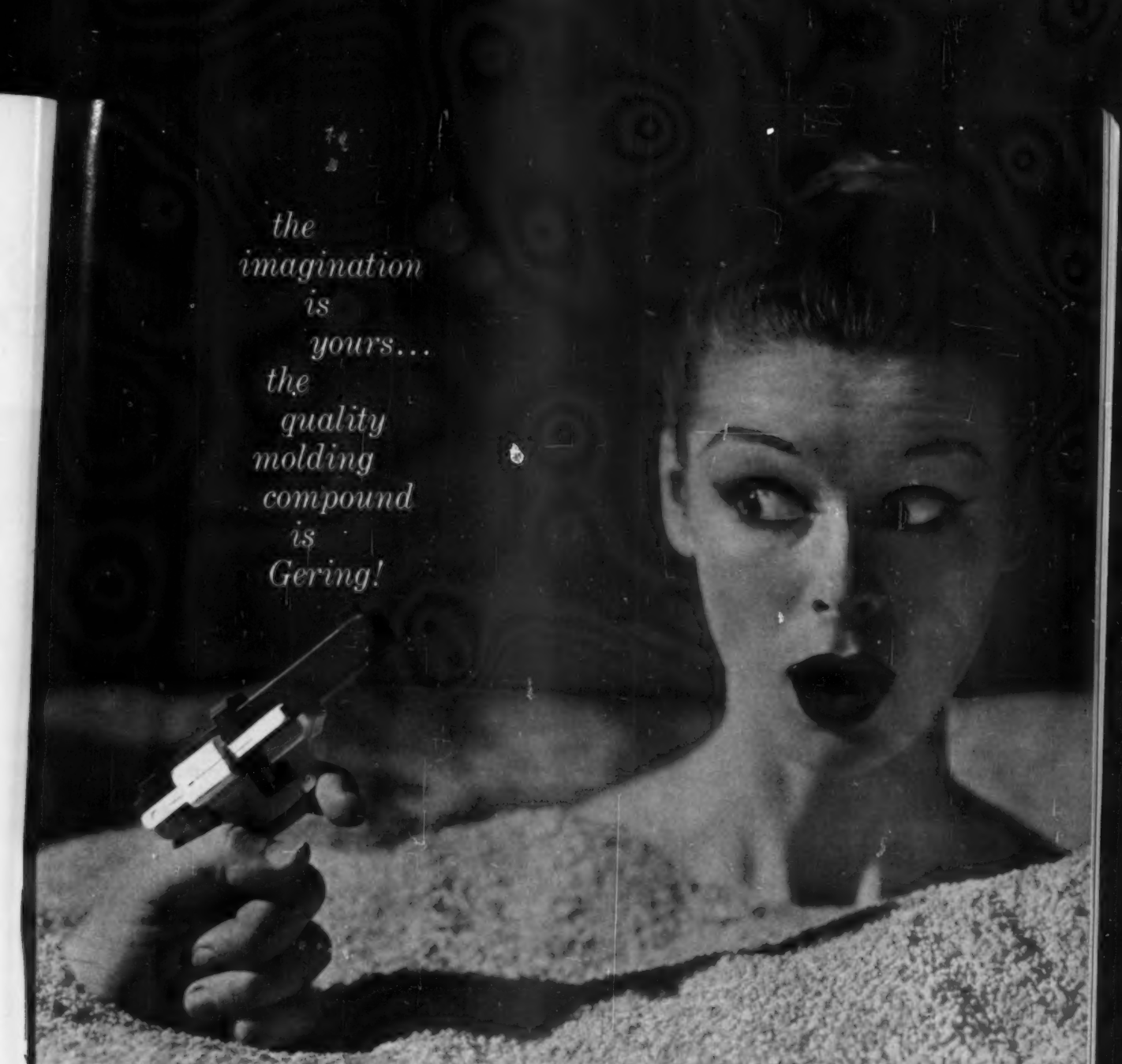
ADDRESS _____

CITY _____ ZONE _____ STATE _____

MAIL THIS COUPON FOR LATEST INFORMATION COVERING

AVISUN **Olefane**

Polypropylene Film



You give your product Form and Function! Quality is assured by teaming up with competitively priced Gering Thermoplastics. They perform as you specify—exact in color, flow and physical properties. Whatever your needs (including flame-retardant formulations), Gering offers a complete range of superior plastic compounds—for extrusion and injection molding! Write today for the cost-saving facts.

Polyethylene • Polypropylene • Vinyl • Polystyrene • Styrene Copolymers • Acetate • Nylon • Acrylic • Butyrate

GERING

Molding Compounds

GERING PLASTICS division of STUDEBAKER-PACKARD CORP.
Kenilworth, N. J.

Cable Address: GERING TWX Cranford, N. J. 137
Sales Offices: 5143 Diversey Ave., Chicago 39, Ill. • 1115 Larchwood Rd., Mansfield, Ohio • 216 Wild Ave., Cuyahoga Falls, Ohio • 103 Holden St., Holden, Mass.

Society of
Plastics Engineers, Inc.

An international scientific and educational organization of more than 7,000 individual members devoted to the development and dissemination of technical information in the fields of research, design, development, production and utilization of plastics materials and products. The Society is incorporated under the laws of the State of Michigan.

Executive and Business Offices
65 Prospect St.
Stamford, Conn.

Officers of the Society

Frederick C. Sutro, Jr., *President*
George W. Martin, *1st Vice President*
Jules W. Lindau, III, *2nd Vice President*
Frank W. Reynolds, *Secretary*
Haiman S. Nathan, *Treasurer*
Thomas A. Bissell, *Executive Secretary*

●

All correspondence relative to business matters, meetings of the Society, membership, advertising and the like, should be addressed to the business offices listed above.

●

Members should notify the business offices at least 30 days in advance of contemplated changes in address.

●

Membership in the Society is available to qualified individuals. Inquiries should be addressed to the business office.

●

Membership in the Society is extended to individuals who by previous training or experience or by present occupation qualify them to carry out the objective of the Society. The privileges of membership are designed to enhance the professional standing of the individual member by encouraging participation in scientific and technical programs and professional activities; by developing close personal contacts and acquaintanceship among members; and by providing an opportunity to administer the local and national activities of the Society.

●

Neither the Society of Plastics Engineers, Inc., nor the SPE Journal is responsible for the views expressed by individual contributors either in articles accepted for publication in the Journal or in technical papers presented at meetings of the Society.

The Society of Plastics

COVER

Three fields of plastics engineering are featured on our **Cover** this month—technology, processing and applications.

SPECIAL FEATURES

Plastics in the New Age of Discovery
W. E. Zisch, Aerojet-General Corp.
Plastics engineers help shape the world of tomorrow ... 1042

TECHNICAL SECTION

The Use of Reground Glass-Filled Polystyrene
George R. Rugger, Picatinny Arsenal, Dover, N. J.
Tests show no strength reduction in molded end product 1053

The Specific Heat of High Polymers
R. W. Warfield, M. C. Petree, and P. Donovan, Naval Ordnance Laboratory
A method for establishing a relationship to mechanical and electrical properties of polymers ... 1055

Fundamental Aspects of Fluidized Bed Coating
Joseph Gaynor, General Electric Co.
Three techniques for coating from fluidized beds ... 1059

The Thermal Incline as an Evaluation Tool in Fluidized Bed Coating
C. J. Metz, Union Carbide Plastics Co.
A method for measuring flow of coating powders at different temperatures ... 1064

Aluminum-Foamed-Plastic Panels
L. W. Hovland, Aluminum Co. of America, and E. R. McLaughlin, Pennsylvania State University
Physical test data on foamed plastic core sandwich materials ... 1066

Continuous Peel Strength Measurement of Copper Clad Laminates
Charles S. Kepple, Motorola Inc.
Bond strengths of copper applied to plastic base panels 1070

Non-Member Subscription Rates

DOMESTIC		FOREIGN	
1 Year	$ 6.00	1 Year	$10.00
2 Years	11.00	2 Years	16.00
3 Years	15.00	3 Years	20.00
*Single Issue	.65	*Single Issue	1.50

**Single issues older than 6 months are charged at $1.00, and single copies of the Roster Issue at $2.00.*

● The SPE Journal is Published at 215 Canal St., Manchester, N.H. Address changes, undeliverable copies and orders for subscriptions should be sent to 65 Prospect St., Stamford, Conn.

● Entered as second-class matter at the Post Office at Manchester, New Hampshire. Accepted at special postal rate provided in paragraph (d-2), Sec. 34.40, P.L. and R., of 1918.

● Copyright by the Society of Plastic Engineers, Inc., 1959. Reproduction in whole or part without written permission is strictly prohibited.

Member of the Audit Bureau of Circulations

Engineers Journal

The Dynamic Mechanical Properties of Epoxy Resin
D. H. Kaelble, Minnesota Mining & Manufacturing Co.
Fundamental studies of viscous and elastic responses of polymers 1071

SPE JOURNAL FEATURES

Speaking of Extrusion—Extrusion of Linear Polyethylene Film
Robert Doyle, Phillips Chemical Co.
Making water-quenched polyolefin films at high speeds 1079

Molding Cycles—Increasing Plasticating Capacities of Injection Molding Machines
D. L. Peters and J. N. Scott, Phillips Chemical Co.
Breaker plate nozzle pushes production rate up 1083

National Action—Membership Message
James R. Lampman, Chairman, Membership Committee, General Electric Co.
An open letter to non-members 1081

Committee Reports—National Council Meeting—October 26, 1959
A staff feature
Society makes progress on broad fronts 1085

DEPARTMENTS

Editor's Notebook 1027
Technical Meetings Calendar 1093
Section News 1090
About Members 1087
Plastics Around the World 1094
Book Reviews 1088
Employment and Service Guide 1098
Advertisers' Index 1100

NEXT MONTH

16th ANTEC—Complete program and abstracts.

Calendering Vinyl Films—Tips on overcoming production problems.

Editor
MELVYN A. KOHUDIC
Editor Emeritus
DR. JESSE H. DAY
Layout and Production
LEE COOPER
Editorial Assistant
A. L. NORVELL
Feature Editors
ERNEST J. CSASZAR, *Moldmaking*
GEORGE LUBIN, *Reinforced Plastics*
B. H. MADDOCK, *Speaking of Extrusion*
LOUIS R. PAGGI, *Molding Cycles*
IRVIN WOLOCK, *Polymer Science*
THOMAS A. BISSELL, *National Action*
SPE Publications Committee
FRANK A. MARTIN, *Administrator*
EUGENE C. QUEAR, *Chairman*
Editorial Advisory Board
FRANK W. REINHART, *Chairman*
ROBERT W. BARBER
LUTHER BOLSTAD
EDWARD F. BORRO, SR.
BENJAMIN S. COLLINS
WILLIAM CROLL
EDWARD J. FITZPATRICK
RUSSELL M. HOUGHTON
HERMAN S. KAUFMAN
JOHN P. LOMBARDI
THOMAS F. McLAUGHLIN
ROBERT E. MONICA
JULES PINSKY
ROBERT D. SACKETT
EDWARD W. VAILL
FREDERICK WEHMER
Advertising Manager
LEON R. NOE
Advertising Representatives
Ohio-Eastern Michigan and Western Pennsylvania
RAYMOND B. MOONEY & ASSOC.
2640 Oatis
Toledo 6, Ohio
GReenwood 5-1140
Central-Midwest
SCOTT KINGWILL & ASSOCIATES
35 E. Wacker Drive
Chicago 1, Ill.
STate 2-4227
Upper Midwest
M. B. BOCK & ASSOCIATES
Baker Building, 7th St.,
Minneapolis, Minn.
FEDERAL 6-9191
West Coast
THOMPSON & CLARK CO.
681 Market St.
San Francisco 5, Calif.
DOuglas 2-8547
and
6000 Sunset Blvd., Rm. 202
Hollywood 28, Calif.
HOllywood 3-4111
Circulation Manager
LEWIS A. BERNHARD

The polyethylene film used to package these Hallmark gift papers is produced by Flex-O-Glass, Inc. of Chicago, using "Poly-Eth" 2756, one of the complete family of "Poly-Eth" Polyethylene resins for overwrap.

Now! A Complete Family of Spencer For High-Speed Automatic

In step with the skyrocketing use of polyethylene film for overwrap, Spencer Chemical Company now offers 3 specialized "Poly-Eth" Polyethylene* resins which can all be used in today's high-speed and automatic overwrap machines.

PACKAGING HISTORY was made recently with the development and acceptance of polyethylene film for overwrap.

There is good reason for the immediate popularity of this new overwrap. Polyethylene film offers many advantages not found in cellophane. And polyethylene film costs substantially less than cellophane.

Spencer Chemical Company was a pioneer in the development of special resins from which polyethylene film for overwrap is made.

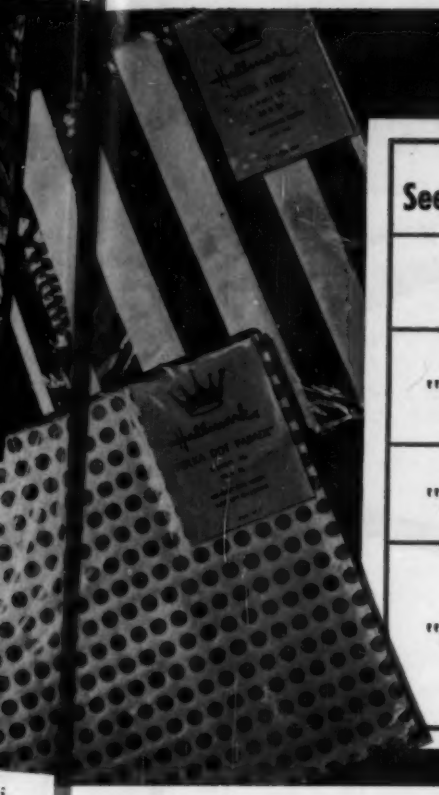
And now, as the widespread use of this new overwrap has produced demands for several specialized types of polyethylene films, Spencer has met these demands by offering a complete "Poly-Eth" family of resins for overwrap. Through Spencer's family of "Poly-Eth" resins a new world of packaging possibilities is opened. (See chart above.)

The polyethylene overwrap that Hallmark, America's largest manufacturer of greeting cards, uses to package gift wrap is illustrative of how each member of Spencer's family of specialized "Poly-Eth" resins is tailor-made to specific overwrap requirements.

*Spencer Chemical Company markets Spencer "Poly-Eth" Polyethylene, from which polyethylene film is made, Spencer "Poly-Pro" Polypropylene and Spencer Nylon. "Poly-Eth" and "Poly-Pro" are trademarks of Spencer Chemical Company.

America's Growing Name In Chemicals

SPENCER®



See Which "Poly-Eth" Resin Best Suits Your Requirements:

Resin	Melt Index	Density	Characteristics
"Poly-Eth" 2756	6	.928	Produces film with improved tear resistance; gloss; excellent clarity and long shelf life. Ideally suited for chill-roll casting method of extrusion.
"Poly-Eth" 2504	1	.935	Produces film with stiffness; clarity; gloss and sparkle; extra moisture vapor proofness and wide temperature resistance.
"Poly-Eth" 2905	2	.940	Produces film with superior texture and feel; excellent moisture resistance; excellent clarity; toughness; stiffness; wide use temperature range and long shelf life. Designed for the fastest overwrap applications. The highest medium density overwrap resin on the market.

"Poly-Eth" Resins Overwrapping

Seeking a new overwrap with high clarity and gloss, excellent tear resistance and long shelf life, Hallmark chooses a polyethylene film made of "Poly-Eth" 2756 resin to package gift wrap.

The Hallmark gift papers your wife buys this month were printed and packaged early last summer.

Because of this, the overwrap Hallmark uses to package gift wrap must have several special qualities. Primarily, it must be tough, crystal-clear and able to withstand long shelf life.

Hallmark finds all of these qualities in a chill-roll cast polyethylene film produced by Flex-O-Glass, Inc., Chicago, Illinois.

This polyethylene film is made of "Poly-Eth" 2756, one of Spencer Chemical Company's complete family of "Poly-Eth" resins for overwrap.

Among the specialized qualities exhibited by film made of "Poly-Eth" 2756 are: Clarity and gloss found only in the best cellophane. Ideal for use in automatic overwrap machines. Unparalleled shelf life. And a lower cost than cellophane.

The exceptional advantages of polyethylene overwrap have led Hallmark Cards to utilize it in packaging other paper products.

At the present, packages of one-dozen Hallmark Valentine Cards are dressed in printed polyethylene overwrap. And in the near future, Hallmark anticipates packaging many more products in strong, low-cost polyethylene overwrap.

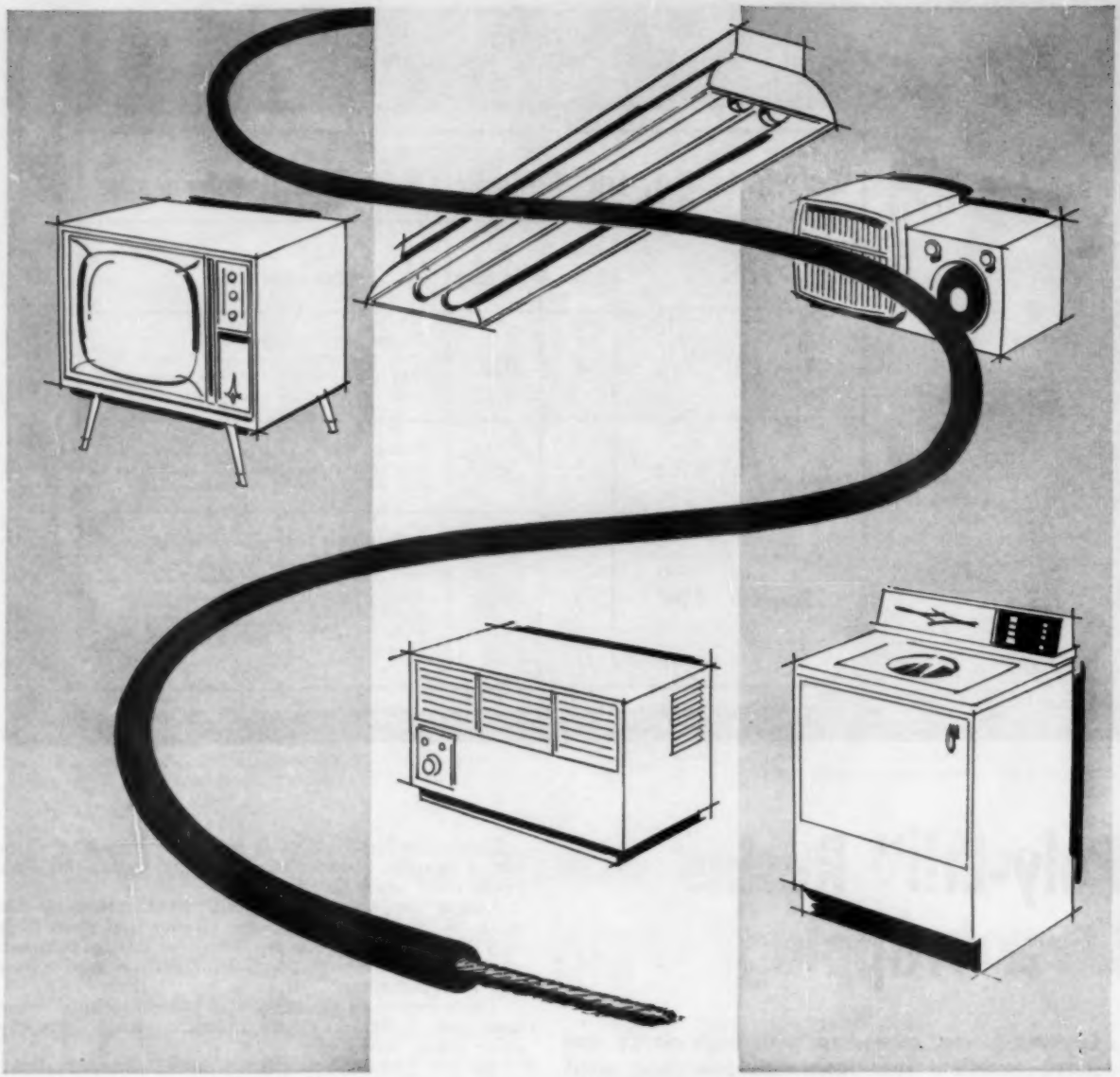
All Easy To Use

Machines now using cellophane may be easily and inexpensively converted for use with polyethylene film made of "Poly-Eth" resins.

Spencer Market Development men will be happy to discuss the application of inexpensive, strong and sparkling polyethylene film to your requirements. For information, contact Spencer Chemical Company at the address below.

Poly-Eth® Polyethylene

Spencer Chemical Company, Dwight Bldg., Kansas City, Missouri



TRIDECYL ALCOHOL

To make DTDP—new low cost plasticizer for high temperature vinyl insulation

Enjay Tridecyl Alcohol is a basic ingredient of ditridecyl phthalate (DTDP), a new high performance plasticizer developed by Enjay Laboratories. DTDP is ideally suited to the manufacture of high temperature vinyl insulation for the electrical industry. The use of this plasticizer will substantially reduce costs at no sacrifice in electrical and mechanical properties. Enjay does not make ditridecyl phthalate but supplies Tridecyl Alcohol for its manufacture.

For further information *about Enjay Tridecyl Alcohol, write or call our nearest office for a copy of Technical Bulletin No. 20.*

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY COMPANY, INC.

15 West 51st Street, New York 19, N. Y.

Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

ENJAY

PETROCHEMICALS

THE EDITOR'S *Notebook*

You Need a Program to Tell

Looking over the many 16th ANTEC papers as they come across our desk, we are reminded of a speech we recently read. The title: "You Can't Tell the Miracles Without a Program." It was a speech directed at advertising managers of the chemical industry. It called attention to the increasingly difficult job of marketing the multiplicity of miracles pouring out of research laboratories. So many products are born of scientific ingenuity, that the miracle is accepted as a common thing!

We have no doubt that many such miracles will be reported at ANTEC in Chicago next month. And, we wonder, how many of us, working in the plastics engineering profession, will take these miracles for granted? Our job ought not be to magnify these accomplishments all out of proportion in the eyes of the lay public. But we should not minimize these accomplishments, either, for much dedicated work and thought has gone into the words behind the titles you will read on the program.

Just as important as the work of preparing the papers is the job of planning, soliciting, screening, and coordinating the program at SPE's ANTECS. Those members who have participated in the past know that such tasks cannot be minimized. They know, too, the challenge of such jobs. Those of us here at SPE headquarters who have seen the preparations for the 16th ANTEC know that the 16th ANTEC Committee members under the able chairmanship of Frank Fine have met the challenge.

You owe it to your fellow members to attend ANTEC. But more important, you owe it to yourself to attend. Among those new ideas will be at least one which will repay you many times over for attending.

For registration information, write or wire 16th ANTEC
Society of Plastics Engineers, Inc.
65 Prospect St., Stamford, Conn.
Attn: Mr. L. A. Bernhard

Next Month is Antec

JANUARY 12-15, 1960
The Conrad Hilton
Chicago, Illinois

Chicago is waiting—for you and for all others concerned with this year's important advances in plastics engineering. The 16th ANTEC Committee has completed arrangements for a conference of high technical quality and unusual membership appeal. You have received your copy of the Advance Program listing names of sessions, titles of papers, and names of contributing authors. All that remains is for you to send in your registration and plan to be on hand!

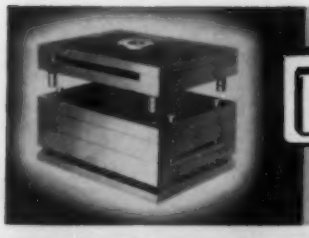
The program for your ANTEC has been designed to give you a choice of technical sessions of your interest *and* the opportunity to play a part in the growing Professional Activity Groups. This year there will be fewer papers presented than at previous ANTECs. But the ones you will hear have been selected from the best of a large number of excellent candidates. Plan to take in as many as possible in the morning and early afternoon sessions. And then at 3:30 P.M., look for your PAG. There you may join in the discussions and participate to the extent you want in the specialized technical activity of that group. You should be rewarded with more knowledge of the

Professional Activities and Approaching Opportunities in the Growth of Plastics Engineering

Charles M. Waugh

Vice Chairman, Program

SPE 1960 Annual Technical Conference



DME Mold Standards

DEDICATED TO QUALITY, SERVICE AND ECONOMY IN MOLDING

YOU SAVE MORE ON MOLD COSTS WITH OVER 6,000 D-M-E STANDARD MOLD BASES TO CHOOSE FROM

Largest Selection Saves You Time and Money

Whether it's a one-cavity "test" mold or a 60-cavity high production run, chances are D-M-E has the right size Standard Mold Base to fit the job and the molding machine.

D-M-E's 32 standard sizes, up to 23¾" x 35½", with 100 standard cavity plate combinations for each size, give you the largest selection of carbon or alloy steel standards available from any single source.

Save on Design Time, Moldmaking Time, Replacement Parts and Delivery

Design time is reduced by using D-M-E's full-scale Master Layouts and Catalog of specifications and prices. Moldmaking time is reduced because all D-M-E plates are precision ground flat-and-square, ready for cavity layout and machining. Exclusive interchangeability gives you the added saving of immediate replacement of any component part. And D-M-E's seven branch offices and warehouses are always fully stocked with Standard Mold Bases and components to meet your delivery requirements.

Cut Costs on Your Next Program

Start saving on your next moldmaking program, no matter how large or small. Take advantage of D-M-E Quality, Service and Economy.

THERE'S NO SECRET To a Fine Finish...

...With D-M-E's Line of Mold Polishing Supplies

Polishing mold cavities to a high lustre that is imparted to the molded piece was once "a well-guarded secret." But with D-M-E's complete line of mold polishing supplies moldmakers are able to attain the particular finish required by the part.

With D-M-E Diamond Compound, mirror finishes are produced in less time and at less cost.

Other time and money saving items for your polishing department include: D-M-E's Felt Polishing Kit, Abrasive Stones, Mold Polishing Compound, Abrasive Mounted Points and D-M-E-'s Mold Cleaner and Rust Preventive.

START SAVING NOW... Contact your nearest D-M-E Branch for full details and prices.

FASTER DELIVERIES FROM COMPLETE STOCKS

Over 1,000 D-M-E Standard Mold Bases always IN STOCK at local D-M-E Branches for IMMEDIATE DELIVERY.

DETROIT MOLD ENGINEERING COMPANY

DME

- DETROIT: 6686 E. McNichols Rd.—CHICAGO: 5901 W. Division St.
- HILLSIDE, N.J.: 1217 Central Ave.—LOS ANGELES: 3700 S. Main St.
- D-M-E CORP., CLEVELAND: 502 Brookpark Rd.—DAYTON: 558 Leo St.
- D-M-E of CANADA, Inc., TORONTO, ONT.: 156 Norseman Ave.

59-A

New 1960 Fords have seat panels molded from scuff-resistant MARLEX*

The all-new 1960 Fords incorporate many innovations in both design and materials. Ford's selection of linear polyethylene for the side shields for the front seat cushions represents *the first major use of this material in the automotive industry!*

Ford used linear polyethylene for this component because it was the only type of material that offered all of the following advantages. (1) Lower piece price . . . *linear polyethylene parts cost ⅓ less than painted steel parts.* (2) Lower tooling price . . . *⅔ the cost of formed steel.* (3) Styling . . . *graining and grooved surfaces obtained easier and at reduced cost.* (4) No seat abrasion . . . *no wear on adjacent upholstery from seat flexure.* (5) Increased scuff-resistance . . . *integral molding of color and graining far superior to painted steel.* (6) No denting . . . *no dent marks in linear polyethylene parts at −20°F to +200°F.* (7) Lighter weight . . . *2.8 lbs. per car less than with steel components!*

Ford ran tests on color and dimensional stability, impact, softening and cycle fatigue characteristics. The linear polyethylene parts proved superior to those made of painted steel. In fact, no other type of material serves so well and so economically for so many different applications.

*MARLEX is a trademark for Phillips family of olefin polymers.

PHILLIPS CHEMICAL COMPANY, Bartlesville, Oklahoma
A subsidiary of Phillips Petroleum Company

PLASTICS DIVISION OFFICES

NEW ENGLAND	NEW YORK	AKRON	CHICAGO	WESTERN	SOUTHERN
322 Waterman Avenue	80 Broadway, Suite 4300,	318 Water Street	111 S. York Street	317 N. Lake Ave.	6010 Sherry Lane
East Providence 14, R. I.	New York 5, N. Y.	Akron 8, Ohio	Elmhurst, Ill.	Pasadena, Calif.	Dallas 25, Texas
GEneva 4-7600	Digby 4-3480	FRanklin 6-4126	TErrace 4-6600	MUrray 1-6997	EMerson 8-1358

PHILLIPS 66 MARLEX

Why Gilbert Plastics Uses Reed-Prentice Injection Machines Exclusively...

"Reed-Prentice gives us top performance and dependability," says Mr. Peter Preuss, Vice President of Gilbert Plastics in Kenilworth, New Jersey. "These REED presses help us get the jump on competition and have helped make Gilbert the largest manufacturer of tomato boats and berry baskets in the country. We've found through experience that Reed-Prentice machines can be counted on to deliver the high quality products we insist on here at Gilbert. REED machines have done more than their share toward building our reputation and growth."

Reed-Prentice injection machines can do the same rugged, dependable job for any molder who wants better, faster molding. REED engineering brings you the most advanced features in injection molding . . . machines designed for today's need with the capacity to handle future requirements as well. For example in the full REED line, you'll find these exclusive features:

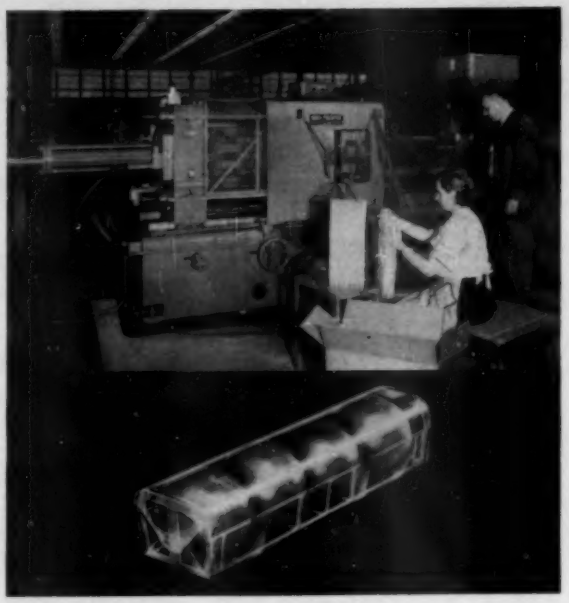
Low pressure die closing mechanism assures complete protection in automatic molding.

Hydraulic die space adjustment allows faster, easier mold setup.

Centralized controls put all controls at operator's fingertips.

Adjustable stroke offers greater flexibility, increases injection capacity.

For complete information and specifications on the full REED line of injection molding machines, call your nearest REED Sales Engineer today.



Above, one of the REED machines running the tomato boat on automatic operation. Below, is the finished product over-wrapped and ready for market.

REED-PRENTICE

division of

PACKAGE MACHINERY COMPANY

EAST LONGMEADOW, MASSACHUSETTS

BRANCH OFFICES: NEW YORK • CHICAGO • BUFFALO • DAYTON • DEARBORN • KANSAS CITY • LOS ANGELES

U.S.I. POLYETHYLENE NEWS

Packaging Notes

A handy polyethylene pump for inflatable items has been marketed by a California manufacturer of air matresses and beach toys.

The pump consists of an open polyethylene bag with a reinforced hole at one lower corner. The polyethylene pump is used by attaching it to the valve of the inflatable item, and fluffing the bag open. Then the top is closed by rolling it. Finally, the bag is squeezed down and rolled to force the air from it into the inflatable item.

Compact First Aid Kits of Polyethylene are being marketed. The inexpensive kits are specially designed for marine use, but outlast metal containers any place where corrosion is a problem. The kits are water, rust, and mildew proof. They also float. The kits are available in two sizes and contain bandages, tapes, ointments, and scissors normally found in first aid kits.

Wholesale jewelers use polyethylene bags to ship their merchandise. The tough polyethylene bags not only give better inspection advantages but they also eliminate heavy returns of jewelry formerly scratched in shipping.

Use of a heat-sealed strip of polyethylene has greatly reduced the difficulty of opening sealed polyethylene bags. This application of polyethylene is now being used by a cake mix producer for easy opening of his package's inner bag.

A ½ inch strip of polyethylene is welded along the width of one side of the bag by a thin line of heat-sealing. It runs 1 inch below the top of the bag and extends ¼ inch from each edge of the bag. When the free end of the strip is pulled, the polyethylene bag tears with it along the heat-seal line.

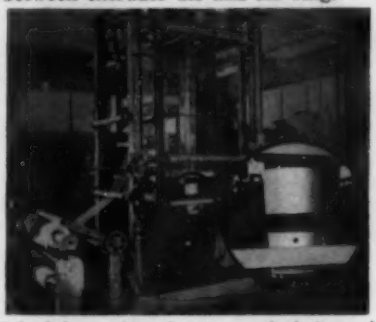
DO YOU HAVE a new polyethylene packaging development you'd like the industry to know about? Make it routine to send your information on new developments to U.S.I. POLYETHYLENE NEWS.

Address the Editor,
U.S.I. POLYETHYLENE NEWS, U. S. Industrial Chemicals Co., Division of National Distillers and Chemical Corp., 99 Park Avenue, New York 16, N. Y.

New U.S.I. Technique Improves Optical Properties of Blown Polyethylene Tubing

Annealing Chamber Increases Light Transmittance, Reduces Haze

The U.S.I. Polymer Service Laboratory has developed an annealing chamber or "chimney" technique which results in significant improvement in clarity and gloss of blown polyethylene tubing, with practically no sacrifice of physical strength. The method, involves installation of a chamber which encloses the blown tubing between extruder die and air ring.



Polyethylene tubing has improved clarity and gloss when produced with new U.S.I. annealing chamber technique. Close-up view shows "chimney" in place between extruder and air ring.

Unit is easy to install

The chimney may be made of wood, glass or insulated metal. It should be constructed in two sections or hinged to permit installation during extrusion . . . thus eliminating need for rupturing the "bubble" when threading film through the annealing chamber.

Height of chimney is an important factor. Optimum results are usually obtained with a 6 to 10" chimney height. While ratio of chimney diameter to die diameter is not critical, it should be held between 2:1 and 3:1. For example: a 3" die would require a 6 to 9" chimney diameter.

An evaluation of PETROTHENE P-200-25 resin using this technique revealed:

Optical Property	*No Chimney*	*8" Chimney*
Transmittance	30%	70%
Gloss	7%	11%
Haze	11%	4%

No significant change was noted in impact strength. Elmendorf tear tests showed that a directional strength balance was brought about by adding the chimney. Tear values increased in the transverse direction and decreased in the machine direction. Yield, break and elongation were essentially unchanged.

Work on this new technique is continuing at the U.S.I. Polymer Service Laboratory, where your inquiries are always welcomed. If you have special problems, U.S.I. engineers will gladly offer their assistance. You are also invited to write for a Technical Data Sheet describing the new process.

Polyethylene "Socks" Used in Causeway Construction

A causeway between Miami and Miami Beach will consist of a number of bridges connecting a series of man-made bulkheaded sand islands. The company building the causeway has found a unique construction use for polyethylene film "socks."

When the sheetpiles that form the bulkheads for the man-made islands are in place, the top pockets or slots between adjacent piles are grouted with mortar to make the wall absolutely tight and prevent loss of sand fill. To prevent leakage of mortar in this operation and to save time in building forms, the contractor devised polyethylene "socks" that fit in the slots to be filled.

A small amount of mortar is placed in the bottom of the "sock." The sock or bag is then allowed to sink into place in the slot and the rest of the mortar is then poured into it. The method is described as an efficient and effective way to seal joints in precast concrete structures, whether in water or in the dry.

Polyethylene is Vacuum Formed on Planting Pots

A midwest company has developed a process for vacuum forming 1 mil polyethylene film around peat moss planting pots.

The pots, which are used to start flowers, vegetables and nursery stock of all types, shorten the plants' growing period, and at the same time, improve their quality.

Photo courtesy A. O. Reynolds Co., Lebanon, Indiana

This vacuum forming of polyethylene has significantly improved the pots' strength by increasing their resistance to water damage. The polyethylene jacket insures a constant supply of water for the plant in the pot. When the plant and its pot are ready to be put in the ground, the polyethylene film strips off easily.

These pots, now being field tested extensively by greenhouses and commercial growers, are molded by drying peat moss paper slurry. The polyethylene film is then vacuum-mated to them.

U.S.I.

Vol. IV, No. 6

POLYETHYLENE PROCESSING TIPS

PROPERTIES THAT AFFECT GREASEPROOFNESS OF POLYETHYLENE COATINGS

As used in the paper coating industry, the term greaseproofness generally refers to conformity of a polyethylene coating with Military Specification MIL-B-121A. This specification defines the grease resistance of polyethylene-coated paper used to package material which is grease-coated for long-term storage.

Under this specification, greaseproofness is tested by measuring the resistance of polyethylene-coated paper to a turpentine solution of a dyed grease. Test conditions require 24 hours exposure to the solution at a specified temperature and relative humidity. To meet the specification, all samples tested must be free of dye color on the uncoated side of the paper at the conclusion of the test period.

Although this specification was drawn up to satisfy the stringent requirements of military applications, it is also employed to define the grease resistance of polyethylene-coated paper to be used for industrial and food applications. However, there are many cases where the requirements of MIL-B-121A may be reduced and still be entirely satisfactory. How far these requirements may be lowered can best be determined through actual tests with the item to be packaged.

Importance of Resin Density and Melt Index

One resin property having an important effect on the greaseproofness of a coating is density. Generally, as resin density is increased from 0.915 to 0.930 and higher, the grease resistance of a polyethylene coating of a given weight improves considerably, as shown graphically in Chart 1. Polyethylene permeability to gases and liquids is similarly affected by density, as previously discussed in this series (U.S.I. Polyethylene Processing Tips, Vol. II, No. 2, and Vol. IV, No. 3). This is to be expected since greaseproofness is one aspect of permeability.

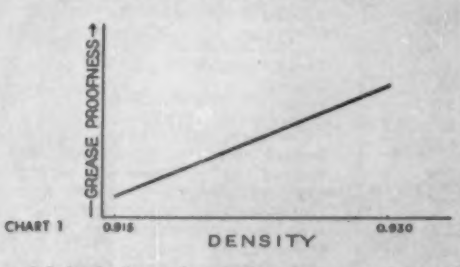


CHART 1

Melt index also influences greaseproofness, decreasing melt index resulting in improved grease resistance. However, melt index has less of an effect than density. Chart 2 shows this relationship.

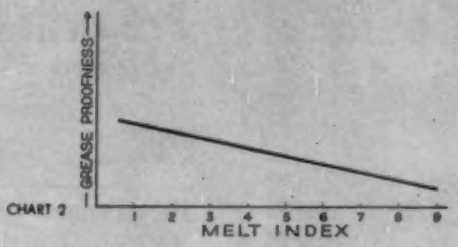


CHART 2

Balancing of Effects

But the paper coater seeking to produce grease-resistant polyethylene coatings cannot consider the effects of density and melt index on grease permeability alone. He must also consider the influence of these properties on the economical operation of his equipment. Such problems as increasing neck-in and curl resulting from the use of higher-density resins must be evaluated before selecting a resin for a given application.

Influence of Coating Weight

Greaseproofness of the finished sheet also depends on the weight of the polyethylene coating applied to the substrate. The greater the coating weight or thickness, the better the grease resistance. With a thicker coating or a resin of higher density, the likelihood of individual paper fibers fracturing the film surface during coating is reduced. With very heavy coatings, however, curl is increased and slower speeds are required.

What Type of Coating?

Theoretically, a heavy enough coating of any polyethylene resin will produce a sheet which will pass MIL-B-121A. But from a practical standpoint, the lowest coating weight which gives the most coverage per pound of polyethylene is an obvious ideal. This can be accomplished by selecting the highest-density resin which has good processibility, acceptable adhesion, and reasonable neck-in, and permits high operating speeds.

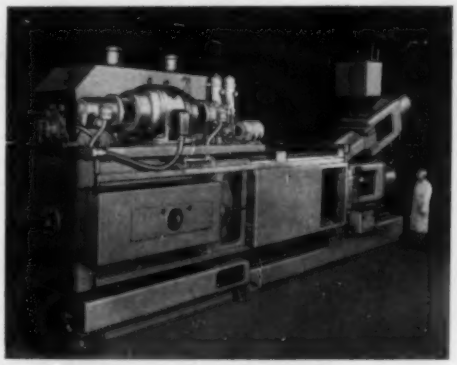
Economical coatings meeting MIL-B-121A requirements can be produced with PETROTHENE® coating-series resins. These resins usually yield a proper balance of properties wherever greaseproofness is the primary objective. Where other objectives are predominant, U.S.I. Technical Service Engineers will be glad to recommend the proper resin for your application. They'll also work with you on any processing problems you have.

U.S.I. INDUSTRIAL CHEMICALS CO.
Division of National Distillers and Chemical Corp.
99 Park Ave., New York 16, N. Y.
Branches in principal cities

This refuse can represents the extra bonus Rubbermaid gets for every 3 cans molded on their new H-P-M 200 oz.

REFUSE CANS MOLDED 50% FASTER

A Report From Rubbermaid, Inc. On The New H-P-M 1000-P-200 Preplasticizer



Here are the "specs" that can put you in a new production class, too: 1000 tons clamping pressure; 200 oz. injection capacity; 65" daylight (79" with ejector box removed); 45" stroke; 39" x 60" mold mounting space; 4050 cu. in. per min. injection rate (5300 cu. in. per min., optional).

M. "Slim" Krajcik, Plastics Supt. for one of the country's top-quality molders, Rubbermaid, Inc., Wooster, Ohio, says, "We are really happy with our new H-P-M 1000-ton machine. We now can mold 3 cans in the same time it took to mold 2 in another make machine. It's the busiest machine in the plant. Maintenance has been negligible."

With 1000 tons clamp pressure, 200 oz. material capacity per "shot", plenty of mold mounting area, and accurate shot control, you'll be amazed at what this machine can do for you. It permits taking on jobs unheard of a few years ago . . . deeper drawn parts with larger projected areas which are now in production, or on the design board. It's turning out such parts at high production rates.

Yes, a couple hundred additional tons clamping pressure is the difference between molding large parts and *really big ones*. With this new H-P-M you can do both, economically. Write for complete information, today.

THE HYDRAULIC PRESS MFG. COMPANY

A Division of Koehring Company, Mount Gilead, Ohio, U.S.A.

DOW **Plastiatrics**

DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

DETERMINING IN-USE TOUGHNESS OF MOLDING MATERIALS REQUIRES STUDIES OF VELOCITY EFFECTS

The terms "impact resistance" and "toughness" are difficult to define, and even more difficult to measure in meaningful terms. In general, impact resistance is considered to be the ability of a material or object to withstand a shock loading, or a stress delivered at a high rate of speed. While toughness also describes a "more-or-less" degree of resistance to breaking, it does not relate to any particular speed, or range of speeds, of loading.

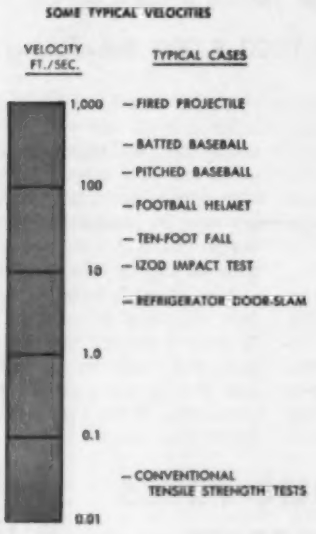
However, since the strength properties of plastics are time dependent, they will vary as the velocity, or time of stress application varies. *These variations are extremely important to the designer or plastics engineer, particularly when the in-use strength of a plastic material is critical to the successful operation of a product or mechanism.*

Some plastics are more sensitive to changes in impact velocity than others, but most have a critical velocity above which they will be brittle and below which they remain strong and ductile. Thus, in selecting a material for design purposes, it is important to know the relative resistance of the plastic to impact AT VELOCITIES OF THE SAME ORDER AS THOSE WHICH THE PLASTIC WILL BE MOST LIKELY TO ENCOUNTER UNDER USE. In-use impact velocities range from about 1 ft./sec. to many hundreds of feet per second. At left (below) are some typical impact sources and the average velocities encountered. The standard Izod impact test is made at about 11 ft./sec. and provides only screening data which is inadequate for most design purposes.

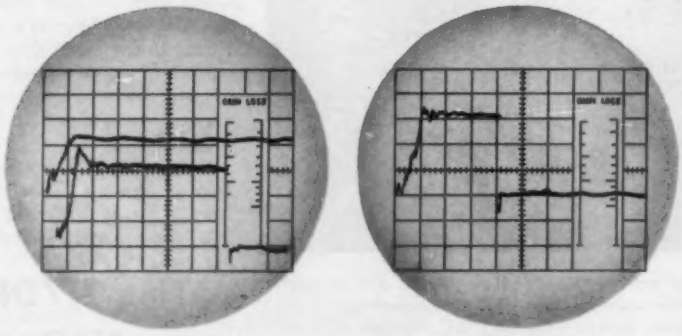
For example, data gathered during a study by Dow Plastics Technical Service Engineers on high-energy shock loadings of various molding materials indicates that resistance to breakage at low impact velocities is often considerably less than at high velocities, depending upon the particular plastic being tested. In some cases, a regular grade of plastic exhibited greater toughness at high velocities than did a so-called shock-resistant grade of the same material. In other cases, it was found that soft materials were as stiff and tough as hard materials of the same general type, under high velocity impact. A typical set of high velocity oscilloscope-recorded stress-strain data from this study is illustrated at right (below).

Further, this study illustrated the strengthening effect of geometry of the molded part, and of molecular orientation which occurs during molding. One plastic material which the Izod impact test interpreted as brittle, with little impact resistance, proved to be highly resistant to high velocity impact *when tested in its final molded form.*

These tests are part of a continuing study by Dow engineers to provide information and assistance to designers and plastics engineers in the most effective selection and use of plastics materials. Some of the results of this study are periodically reported in articles such as this, while detailed results and data are available in more complete form on request.



The range of impact velocities encountered in actual use by plastic materials, and typical impact sources which generate them.



Oscilloscope patterns of stress and strain to fracture of a typical plastic at high velocity. High velocity tests often completely reverse toughness findings which result from standard low velocity or static testing.

DOW **Plastiatrics**

DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

GET THE COMPLETE SERIES OF PLASTIATRICS ARTICLES, BOUND IN CONVENIENT BOOKLET FORM!

You can now get reprints of all five articles in this current Plastiatrics series, bound in convenient booklet form. Accompanying the booklet will be supporting technical bulletins which expand on the subject matter of each article in great detail. The articles themselves provide data and technical information of interest to designers and plastics engineers in all fields.

If your work with plastics materials includes designing, engineering, specifying, or production control, we will be glad to send you a copy. Just use the coupon below, or request a copy on your company letterhead.

Following is a brief description of each of the articles contained in the booklet:

CLASSIFICATION OF DATA

Defined are five basic types of data normally employed for describing the properties of materials. The limitations and use of each type of data are described, together with examples of each.

EXPANDING DATA BASE

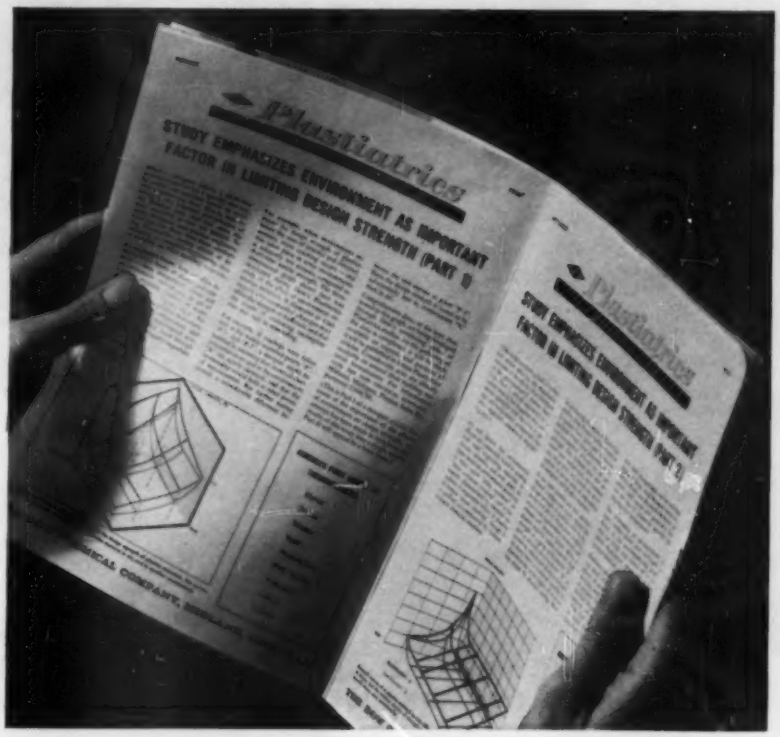
This article carries the discussion above one step further, and provides a detailed example of how quality control data must be expanded to permit screening of materials over a wider range of measurements.

THREE-DIMENSIONAL ANALYSIS

The use of three-dimensional analysis of plastics materials data is shown. The article explains the function of this method as a design tool in determining the full potential value of a plastic under consideration.

ENVIRONMENT STUDY

This two-part article describes the variable effect of environment on the working strength of plastics materials, and the necessity of testing under the environmental conditions to be encountered during actual use of the finished product.



AMERICA'S FIRST FAMILY OF THERMOPLASTICS

STYRON*
ZERLON* • ETHOCEL*
TYRIL*
SARAN • POLYETHYLENE
PVC RESINS
PELASPAN*

*Trademark

Plastics Sales Department 2102EX12.
THE DOW CHEMICAL COMPANY
Midland, Michigan

Please send my copy of the complete 1959 Plastiatrics Studies brochure to:

Name: _____ Title: _____

Company: _____

Address: _____

City: _____ Zone: _____ State: _____

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

SYMPHONY OR SWING RECORDS ARE BEST WITH
WITCO-CONTINENTAL CARBON BLACKS

For top performance, from record press to player, specify Witco-Continental Carbon Blacks. The high electrical conductivity of Witcoblaks® HAF and ISAF eliminates annoying static... lower needle noise increases listening enjoyment. For your next batch, be sure to specify Witco.

There's a Witco-Continental Carbon Black exactly right for *every* plastics application. Write today for technical details of Witcoblaks suitable for your plastic products.

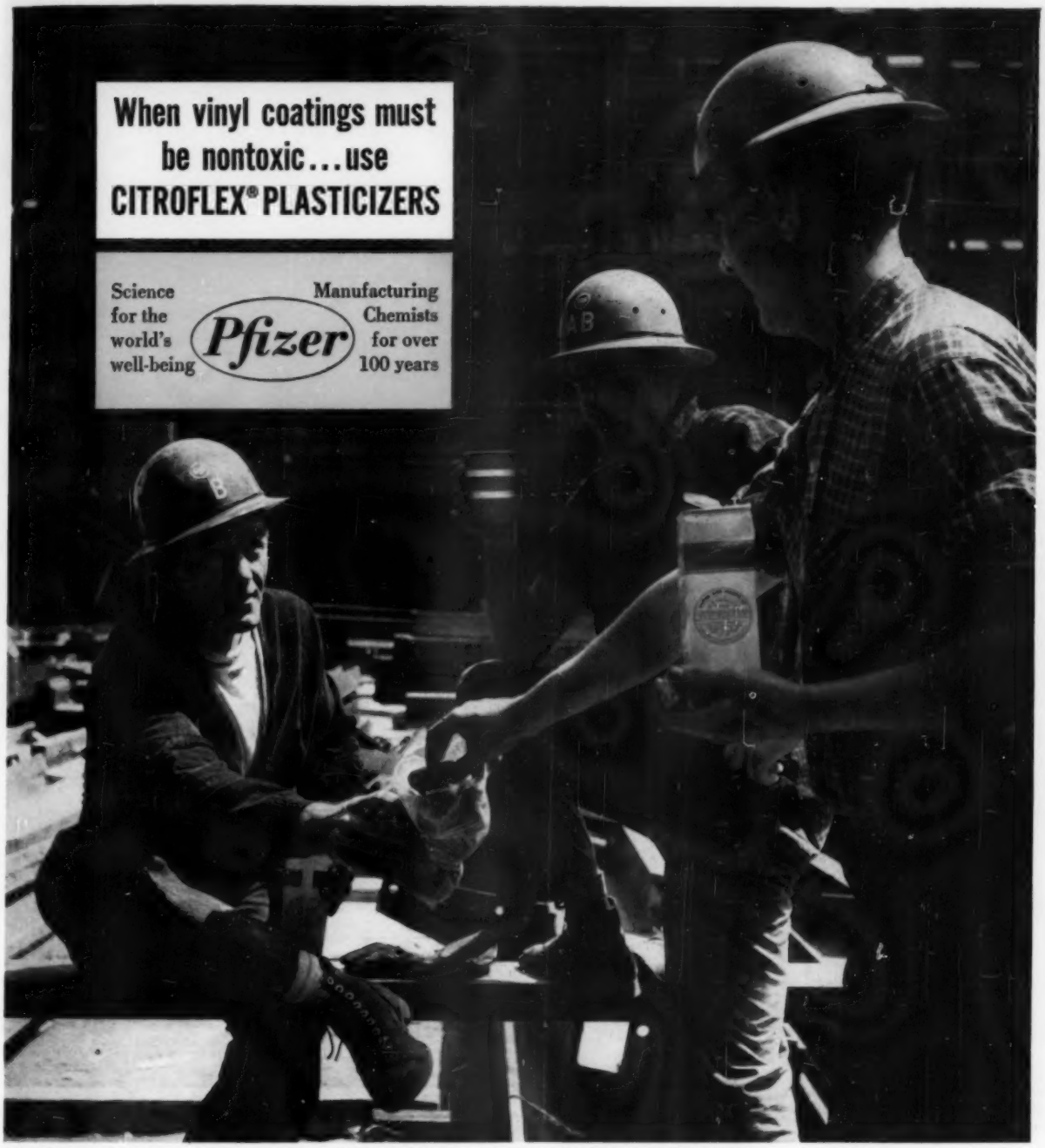
WITCO CHEMICAL COMPANY · CONTINENTAL CARBON COMPANY

122 East 42nd Street, New York 17, N. Y.

Chicago · Boston · Akron Atlanta Houston · Los Angeles · San Francisco · London and Manchester, England

Toronto and Montreal, Canada (P.N. Soden & Co. Ltd.)

WITCO®


When vinyl coatings must be nontoxic...use CITROFLEX® PLASTICIZERS
Science for the world's well-being
Pfizer
Manufacturing Chemists for over 100 years

PLASTIC COATED CUPS • FOOD WRAPPINGS • FATTY FOOD CONTAINERS

• For many plastic coatings, packaging films and plastisols where toxicological safety is important Pfizer Citroflexes are the best possible plasticizers ...and surprisingly economical!

Odorless, as well as nontoxic, Pfizer Citroflex A-2 and A-4 have been accepted by the Food and Drug Administration for use in packaging *both fatty and non-fatty foods.*

CITROFLEX A-4 (Acetyl Tributyl Citrate) for polyvinyls—shows excellent results in plasticizing vinyl films for meat wrapping, vinyl coatings for food containers and hot drink cups, vinyl plastisols for bottle crown liners and food jar sealing rings.

CITROFLEX A-2 (Acetyl Triethyl Citrate) is especially suited for cellulosic packaging materials used for doughnuts, processed meats, etc.

When you need a *safe,* efficient, *economically-priced* plasticizer, take a look at the Pfizer CITROFLEXES.

CHAS. PFIZER & CO., INC. • *Chemical Sales Division* • 630 FLUSHING AVENUE, BROOKLYN 6, N.Y.

Branch Offices: Clifton, New Jersey • Chicago, Illinois • San Francisco, California • Vernon, California • Atlanta, Georgia • Dallas, Texas • Montreal, Canada

Naugatuck KRALASTIC

RESIN-RUBBER COMPOUNDS

KRALASTIC molding and extruding compounds are unique combinations of thermoplastic resins and nitrile rubber. The result is an almost indestructible end product of exceptional strength, toughness and impact resistance.

Extruded as plastic pipe, Kralastic has proved phenomenally successful and durable in transporting salt water and sour crude in the oil fields; carrying natural gas, drinking water, corrosive chemicals, irrigating water; and as money-saving, quickly-installed electric conduit.

With the recently introduced Kralastic HTHT (high temperature, high tensile) and the dramatic new Kralastic MM, a compound so tough, so resistant to heat, staining and abrasion it rivals nylon, the Kralastics offer molders and users everywhere a combination of properties that is truly exceptional.

Consult us for experienced application advice, for information on independent test results, for whatever assistance you may require.

Helmets of practical description are light colorful, easily molde and impact resistant Kralastic can make the

PROPERTY	UNITS	ASTM TEST METHOD	KRALASTIC B	KRALASTIC F	RALAST
PHYSICAL					
Specific Gravity (Natural Color)*			1.06	1.04	
Impact Strength (¼" Bar Sample)					
Izod Notched, 73°F.	ft. lbs./in. notch	D256-56	5-9	3-6	
Izod Notched, 32°F.	"	"	1.8	1.5	
Izod Notched, −40°F.	"	"	0.6	0.4	
Charpy Unnotched, 73°F.	ft. lb./in.	"	35-58	28-42	
Charpy Unnotched, 32°F.	"	"	35-50	40-45	
Charpy Unnotched, 0°F.	"	"	35-50	21-26	
Charpy Unnotched, −40°F.	"	"	8	6-8	
Compressive Strength	psi	D695-54	6,400	5,800	
Compressive Modulus	psi	D695-54	290,000	280,000	
Flexural Strength	psi	D790-49T	8,000	7,500	
Flexural Modulus	psi	D790-49T	260,000	250,000	
Tensile Strength	psi	D638-52T	5,500	5,000	
Hardness, Rockwell	R Scale	D785-51	96	92	
Thermal Coefficient of Expansion	in./in./°F.	D696-44	0.000056	0.000056	
Thermal Conductivity	B.T.U./hr./ft.² per°F./in. Cal/sec./cm²/°C./cm	C177-45	1.7 0.00060	2.0 0.00069	
Specific Heat	B.T.U./lb./°F.		.37	.36	
Deflection Temperature, 264 psi	°F.	D648-45T	187	185	
Water Absorption, 24 hrs.	% Gained	D570-54T	0.3	0.2	
Compression Ratio (Bulk Factor)		D392-38	1.8-2.0	1.8-2.0	
Compression Molding					
Temperature	°F.		325-400	325-400	
Pressure	psi		1000+	1000+	
Injection Molding					
Temperature	°F.		375-600	350-600	
Pressure	psi		6,000-30,000	6,000-30,000	
Mold Shrinkage (Average)	in./in.		.004-.005	.004-.005	
Extruding Temperature	°F.		350-450	350-450	
Calendering Temperature	°F.		350-400	325-400	
ELECTRICAL					
Dielectric Strength Short Time ⅛"	Volts/Mil	D149-55T	312	351	
Volume Resistivity (35% Relative Humidity at 73°F.)	Ohm/Cm.	D257-54T	1.8×10^{13}	1.1×10^{13}	
Dielectric Constant		D150-54T			
60 CPS		"	4.76	4.15	
1000 CPS		"	4.45	4.20	
10^6 CPS		"	3.78	3.61	
3000 x 10^6 CPS		"	2.76	2.70	
Dissipation Factor		D150-54T			
60 CPS		"	0.021	0.015	
1000 CPS		"	0.002	0.002	
10^6 CPS		"	0.026	0.026	
3000 x 10^6 CPS		"	0.006	0.006	
Loss Factor		D150-54T			
60 CPS		"	0.101	0.062	
1000 CPS		"	0.010	0.007	
10^6 CPS		"	0.099	0.094	
3000 x 10^6 CPS		"	0.016	0.015	

*Specific gravity of colors will vary with the pigmentation used.

†Heat distortion of 225°F. is obtained by annealing for 2 hours at 220°F.

These KRALASTIC materials are arranged in order of decreasing Impact Strength except J, L and HTHT, which have special outstanding properties.

Pipe, valves, and fittings of Kralastic are extremely tough, noncorroding, easy to install, approved for drinking water. A proven superior product in over 9,000 miles of installation.

Large formed parts have high dimensional stability, excellent resistance to most chemicals, and high mechanical strength even in thin sections.

Distinctive Properties:

- High impact resistance
- Extreme toughness combined with hardness
- Lightweight: ½ weight of aluminum; 1/7 weight of iron
- Noncorrosive, nonelectrolytic
- Readily sawed, drilled, and threaded
- Quickly solvent welded
- Dimensionally stable over a wide temperature range
- Opaque built-in colors

Major Uses:

- Pipe and pipe fittings
- Light wheels, gears and pulleys
- Durable hair combs
- Machine housings and parts
- Textile warp tubes and bobbins
- Radio and camera cases
- Football and safety helmets
- Tote boxes
- Hose nozzles and fertilizer injectors

TIC F	RALASTIC 2907	KRALASTIC MM (Formerly Kralastic 2590)	KRALASTIC D	KRALASTIC J	KRALASTIC L	KRALASTIC HTHT
.04	1.06	1.07	1.05	1.02	1.02	1.08
3-6	1.5-3.5	0.7-1.5	0.4-1.3	6-9	5-7	3-4
1.5	1.8	0.7	0.4	5-6	3-5	2.0-2.5
0.4	0.3-0.8	0.4	0.4	1-3	1.5-2.5	0.3-0.5
42	30-50	20-30	23-33	25-35	30-45	30-50
45	—	—	23-33	25-30	—	20-30
26	—	—	10	—	30-40	15-25
-8	25	20	8	35-40	30-40	10-15
0	10,500	11,000	9,000	4,000	5,600	10,000
0	350,000	370,000	430,000	190,000	200,00	290,000
0	11,500	13,500	11,500	4,000	6,500	12,000
0	400,000	450,000	390,000	170,000	275,000	370,000
0	7,800	8,800	6,500	3,000	4,000	8,000
?	115	118	108	62	88	116
?	0.000042	0.000032	0.000047	0.000073	0.000048	0.000038
)	1.6	1.8	1.7	2.1	2.3	2.5
)	0.00057	0.00062	0.00058	0.00072	0.00079	0.00086
	.37	.38	.37	.38	.40	.37
	198	200	193	172	175	225†
	0.3	0.3	0.2	0.2	0.2	0.2
	1.8-2.0	1.8-2.0	1.8-2.0	1.8-2.0	1.8-2.0	1.8-2.0
	325-400	325-400	325-400	325-400	325-400	350-500
+	1000 +	1000 +	1000 +	1000 +	1000 +	1000 +
	375-600	350-600	350-600	350-600	350-600	400-600
	6,000-30,000	6,000-30,000	6,000-30,000	6,000-30,000	6,000-30,000	6,000-30,000
	.004-.005	.004-.005	.004-.005	.004-.005	.003-.004	.004-.008
	350-400	350-450	350-450	350-450	350-450	400-500
	—	—	325-400	300-375	300-375	—
	385	386	350	340	384	363
	$>2.7 \times 10^{15}$	$>2.7 \times 10^{14}$	$>10 \times 10^{13}$	0.54×10^{13}	1.3×10^{13}	$>10 \times 10^{13}$
	3.17	3.10	3.41	4.00	3.70	3.54
	3.12	3.08	3.54	4.47	3.52	3.43
	3.08	3.02	3.20	4.05	3.48	3.24
	—	—	2.66	2.80	—	—
	0.005	0.004	0.009	0.011	0.073	0.034
	0.005	0.005	0.002	0.002	0.008	0.012
	0.009	0.010	0.017	0.018	0.020	0.021
	—	—	0.003	0.008	—	—
	0.016	0.012	0.030	0.043	0.270	0.120
	0.016	0.015	0.005	0.010	0.028	0.040
	0.028	0.030	0.053	0.072	0.069	0.067
	—	—	0.009	0.021	—	—

United States Rubber

Naugatuck Chemical Division, NAUGATUCK, CONNECTICUT

Rubber Chemicals • Synthetic Rubber • Plastics • Agricultural Chemicals • Reclaimed Rubber • Latices

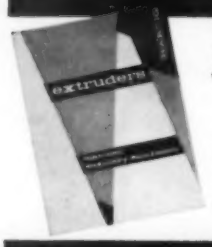
FOR EXTRUDING PACKAGING MATERIALS

with **POINT-OF-SALE**

PUNCH

There's a
HARTIG EXTRUDER
and Matched Auxiliary Equipment
for ***every job requirement***

size, inches	L/D ratio	effective length of screw, inches	nominal capacity lbs/hr	heat on barrel no. of bands	watts per band (max.)	control zones barrel	control zones die head	temp. controls (proportioning) number	thrust bearing capacity, lbs	floor dimensions, inches	weight approx. lbs	motor-drive hp
1½	21:1	31¼	30-40	4	1750	2	1	3	16,380	50 x 26	1250	3
2½	15:1	38	70-95	6	2500	2	1	3	71,100	66 x 41	3200	10-15
	21:1	53⅜	100-130	9	2500	3	1	4	71,100	81 x 41	3500	10-15
	24:1	60¼	110-150	10	2500	3	1	4	71,100	88 x 41	3800	10-15
	30:1	75⅛	120-170	14	2500	4	1	5	71,100	100 x 41	4000	10-15
3½	21:1	73½	210-280	13	2500	3	1	4	221,900	111 x 70	5000	25-40
4½	15:1	60⅝	220-300	9	2500	4	1		221,900	105 x 70	5550	40-50
	21:1	93½	300-420	16	3200	4	1	5	221,900	138 x 70	6000	40-60
	24:1	108¼	350-480	19	3200	4	1	5	221,900	153 x 70	7000	40-75
	30:1	135	410-540	24	3200	5	1	6	221,900	180 x 70	8000	40-75
6	15:1	89⅞	400-530	10	6000	4	1	5	279,500	148 x 82	7200	50-80
	21:1	125⅞	550-750	14	6000	4	1	5	279,500	183 x 82	8000	50-100
	24:1	144½	630-860	20	6000	5	1	6	279,500	203 x 82	8500	50-150
	30:1	180¼	700-950	26	6000	6	1	7	279,500	236 x 82	9000	50-200
8	15:1	112	700-950	15	8000	4	1	5	370,000	179 x 100	8200	75-150
	21:1	168	1000-1300	22	8000	5	1	6	370,000	234 x 100	9000	75-200
	24:1	192	1100-1500	26	8000	5	1	6	370,000	258 x 100	10,000	125-250
	30:1	240	1200-1700	34	8000	6	1	7	370,000	306 x 100	12,000	150-300
10	21:1	210	1500-2100	30	8500	5	1	6	465,000	310 x 120	13,000	150-300
12	7:1	84	1000-1500	9	10,000	2	1	3	525,000	206 x 125	11,500	200-300
	21:1	252	2300-3000	30	10,000	5	1	6	525,000	365 x 125	17,500	200-350



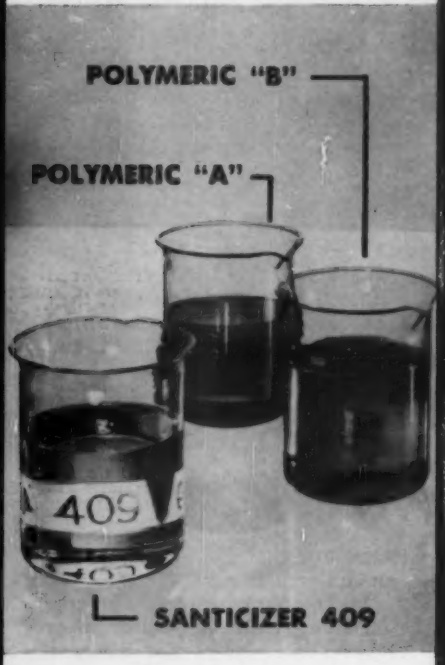
Send for Your Copy

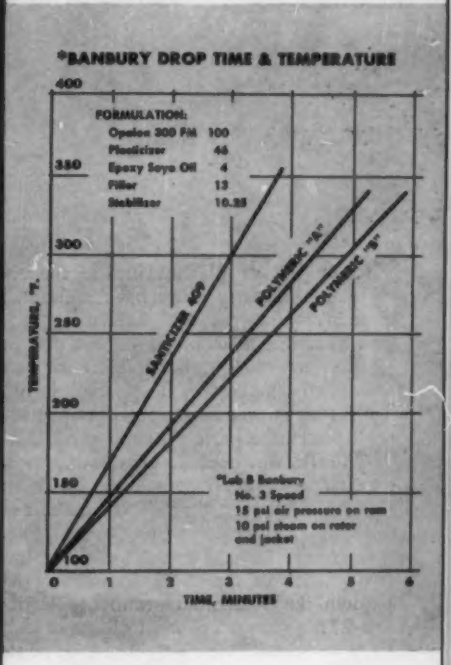
of the new illustrated booklet describing the line of Hartig Extruders and Matched Auxiliary Equipment.

HARTIG EXTRUDERS

Division of Midland-Ross Corporation
MOUNTAINSIDE, NEW JERSEY

Monsanto's new SANTICIZER 409 gives "high-priced" properties at the lowest cost of any polymeric plasticizer!





"Permanent" Benefits

To end summer "fog-up" on car windows from plasticizer volatilization (the most urgent problem confronting vinyl upholstery and coating producers), SANTICIZER 409 offers the best, lowest-cost answer. Simulated service tests prove it stays in the product longer than many higher-priced polymerics. SANTICIZER 409 is less volatile, does not migrate or exude—even in high humidity—as do many other polymeric plasticizers. Also, it is more resistant to extraction by soapy water, alkalies, solvents and oils, and has superior electrical properties.

Lighter Color, Lower Odor

Compared to two commercial polymeric plasticizers (above), SANTICIZER 409 has a lighter, clearer color and far less odor. Its good heat and light stability help finished products retain their true colors, plasticity, attractive appearance and other important physical properties. SANTICIZER 409 contains no flocculent matter or sediment to cause spotting in thin films, transparent sheeting and similar products. Its high purity contributes to excellent electrical properties in vinyl insulating compounds.

Fastest Fusion

SANTICIZER 409 speeds the fusion of vinyl compounds faster than many other polymerics. Its high solvating power, low viscosity and plasticizing efficiency may cut your processing time, or improve your compound's physical properties within your processing temperature limitations. SANTICIZER 409 mixes readily with a variety of monomeric plasticizers and is highly compatible with cellulose acetate butyrate, nitrocellulose, polyvinylidene chloride and PVC.

- If you now use or can use a polymeric-type plasticizer, you can't afford *not* to evaluate new SANTICIZER 409. Use-rated and job-proved, it can give you exclusive advantages *at lowest cost* in products such as: electrical-grade plastisols; coatings for moisture and corrosive-fume protection of dishwashers, ventilator ducts and similar products; long-service profile extrusions such as refrigerator gasketing; coated fabrics, film and sheeting, adhesive-backed tapes and free films.

Write on your company letterhead for a sample of SANTICIZER 409 and compounding help from Monsanto's Plasticizer Council.

SANTICIZER: Monsanto T.M., Reg. U.S. Pat. Off.

Monsanto

WHERE CREATIVE CHEMISTRY WORKS WONDERS FOR YOU

For Technical Bulletins, Use Coupon

Monsanto Chemical Company, Organic Chemicals Division
Plasticizer Dept. 4, St. Louis 66, Missouri

Please send me the ☐ Technical Bulletin on SANTICIZER 409

☐ Research Report on "Fogging in Automobiles"

Name.....

Company.....

Address.....

City.....*Zone*.....*State*.....

Plastics in the World of Tomorrow

Plastics in the New Age of Discovery

W. E. Zisch, *Vice President and General Manager, Aerojet-General Corp.*

The use of plastics in the rocket-missile industry dates back almost as many years as the industry itself, which first became of importance in the early 1940's, being used as protective shells for droppable liquid JATO's and as heat barriers to protect the metallic parts on solid propellant JATO's. But because of war-time production imperatives and the let-down which followed that effort, it was not until 1951 that Aerojet-General took any real interest in the potential importance of this work by starting its own developmental group in plastics

This group, like most others of that time, conducted a seat-of-the pants operation. By trial and error, procedures were found and equipment was developed to produce very useful products, such as high pressure gas bottles, insulation for flame throwers and laminated warhead cones. Finally in 1956 the company recognized the future place of plastics in the rocket industry by establishing a Structural Plastics group as an operating division of the company and by equipping this new division with the facilities and tools for a more scientific approach.

At Aerojet-General work is restricted primarily to the thermosetting class of plastics, used in company with glass fiber or metallic reinforcement. The uses fall mainly into three types of components; structural, insulative and ablative. A large part of our use of plastics is in metal laminating using epoxy and phenolic adhesives.

Aerojet's philosophy in the use of plastics is simple. Use them where they will perform better than other materials, preferably at a lower cost. But in a longer range point-of-view, we see a vastly expanding use of reinforced plastics and adhesive-bonded structures. The reasons are simple;

(1) The properties of reinforced plastics are attractive because of their strength-to-weight ratio, their thermal and electronic insulating qualities and their logistic characteristics.

(2) By adhesive bonding we can build complex, prime and secondary structures using pre-heat treated or unweldable materials. This results in better strength-to-weight ratios, improved section characteristics and reduced costs. These are all important factors in rocket and missile production and performance.

(3) The use of reinforced plastics as ablating insulations solves many problems in rocket nozzles and aerodynamic surfaces where flame temperatures exceed the useful service temperature of any available metals and refractories.

The personnel and equipment at Aerojet-General are oriented for highly specialized operations. Half the technical staff is comprised of mechanical engineers and structures people, emphasizing our belief that a greater engineering understanding is necessary before we can put the unusual structural properties of plastics to work. There has been built up through the years a good knowledge of chemistry and physics of plastics. The scientific application of reinforced plastics has tended to lag. Consequently, in the past, poor design, because of lack of attention to things like tensile and flexural modulus, compressive and bearing strengths, frequently resulted in parts that didn't work properly. It is in this area that real progress has been made and where continuing attention is focused.

Now what does this mean to the plastics industry. This year, it is estimated that out of Aerojet-General's total sales volume of $350,000,000, about 4%, or $14,000,000 was directed toward plastics activities. Perhaps half of this, or $7,000,000 represented orders upon suppliers for various materials and parts associated with plastics work.

Within five years, it is visualized that 20% of our business per year will be directed toward plastics activities. Half of this total represents orders to suppliers in the plastics field.

It takes no great or unusual imagination to see a great plastics boom in the 60's. The strides made in the last few years in winning acceptance for plastics in many uses undreamed of at the end of the last war are evidence that plastics will be a major component of the space age and of the nuclear age which are now the parallel cosmic attractions of all civilized humanity.

The world of tomorrow certainly will be shaped in large measure to the specifications—so far as materials are concerned—which plastics engineers will help discover and develop.

What is Needed to Help Plastics have Broader Application in the Missile-Aircraft-Rocket Industry

Increased efforts at education.

An exacting set of quality control standards for materials and processes.

An industry-wide standardization of materials, issuance of a design manual, clarification of manufacturing methods and the limitations of each, reasonable manufacturing tolerances for various classes of materials, and general advice on design practice and material selection.

CATALYSTS
expressly for
ONE-SHOT
URETHANE FOAM

Dibutyltin dilaurate
Dibutyltin di-2-ethylhexoate
Stannous octoate
Stannous oleate

and **NOW,**
CATALYST T-9
(octoate type)
. . . a new urethane foam catalyst specially processed to give unsurpassed performance in any foam system. No "fade-out" in catalytic action.

One of the M&T catalysts listed above is essential to the success of almost every current one-shot urethane foam formulation. Having pioneered the development of these compounds, M&T keeps abreast of the rapidly advancing technology of their use and can offer practical technical service to those responsible for developing one-shot foam systems. For technical data sheets or other technical assistance, write or call.

M&T Chemicals

METAL & THERMIT Corporation,

Sn Sb P Si Ti Zr inorganics and organometallics

Rahway, N. J.

Another new development using

B.F.Goodrich Chemical *raw materials*

Now gas comes home through pipe of Geon

The pipe in this natural gas distribution system is made of Geon rigid vinyl. Years from now it will be feeding gas to homes just as efficiently as the day after installation. This pipe stays smooth inside and out because it is not affected by the corrosive influences that affect ordinary pipe. No problems from salt water, chemicals, acid or alkaline soils, or galvanic corrosion.

Conduit or pipe made of Geon provides high tensile and impact strength. It stands up under pressure, resisting effects of fungi, bacteria, moisture, heat or cold. It makes a big hit with installation crews, since it is so light weight and so easy to install.

Engineers are taking advantage of the properties of versatile Geon polyvinyl material for this and many other types of applications. For information, write Dept. AJ-5, B. F. Goodrich Chemical Company, 3135 Euclid Ave., Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

1¼" diameter pipe of Geon rigid vinyl is being installed by Illinois Power Company in gas lines leading to homes at Decatur, Illinois. In addition, ¾" vinyl pipe is being inserted in reamed-out 1¼" iron pipe under streets to avoid breaking the pavement to repair leaking gas lines. Kraloy Plastic Pipe Company, Los Angeles, California, makes the pipe. B.F.Goodrich Chemical Company supplies the Geon rigid vinyl.

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich

GEON polyvinyl materials • HYCAR rubber and latex • GOOD-RITE chemicals and plasticizers

IF PHENOLICS CAN DO IT,

99 999,999/1,000,000 % PURE!

Just a fingerprint—yet the amount of salt deposited by it is enormous compared to the infinitesimal (less-than-one-part-per-million) chloride content a modern electrolytic capacitor can tolerate. When the chloride limit is exceeded, even slightly, corrosion begins.

"Maintaining this extremely low level," cautions P. R. Mallory & Co., Inc., one of the country's leading producers of capacitors, "calls for a great deal of cooperation between our material suppliers and our handling methods . . ."

The problem presented to Plenco by Mallory engineers was thus precise and challenging: *Provide a phenolic compound for the molding of capacitor casings that is within one part per million chloride-free.* In addition, other vital requirements for the plastic cases demanded minimum moisture absorption, dimensional stability and maximum heat resistance.

Special needs in a special combination. A challenge that was met in typical Plenco fashion. By adhering to uncompromising standards of research and quality manufacture, Plenco engineers created a custom-designed formulation that ideally answers the exacting Mallory specifications. Result: Mallory Plastic Case Electrolytic AC Capacitors—virtually 100% chemically pure—are as failureproof as electronics science and advanced phenolics engineering can make them. Capacitors that are outstanding for dependability in their countless applications, and are recognized to be the standard of the industry.

Through a broad background of specialized knowledge and success-tested experience, as well as an extensive selection of general and special-purpose phenolic molding compounds, Plenco contributes importantly to many industries. We'd like the opportunity to demonstrate that to you. Call us for consultation at any time.

PLENCO PHENOLICS
FOR BETTER PLASTIC PRODUCTS

PLENCO

PHENOLIC MOLDING COMPOUNDS

. . . already made or specially made

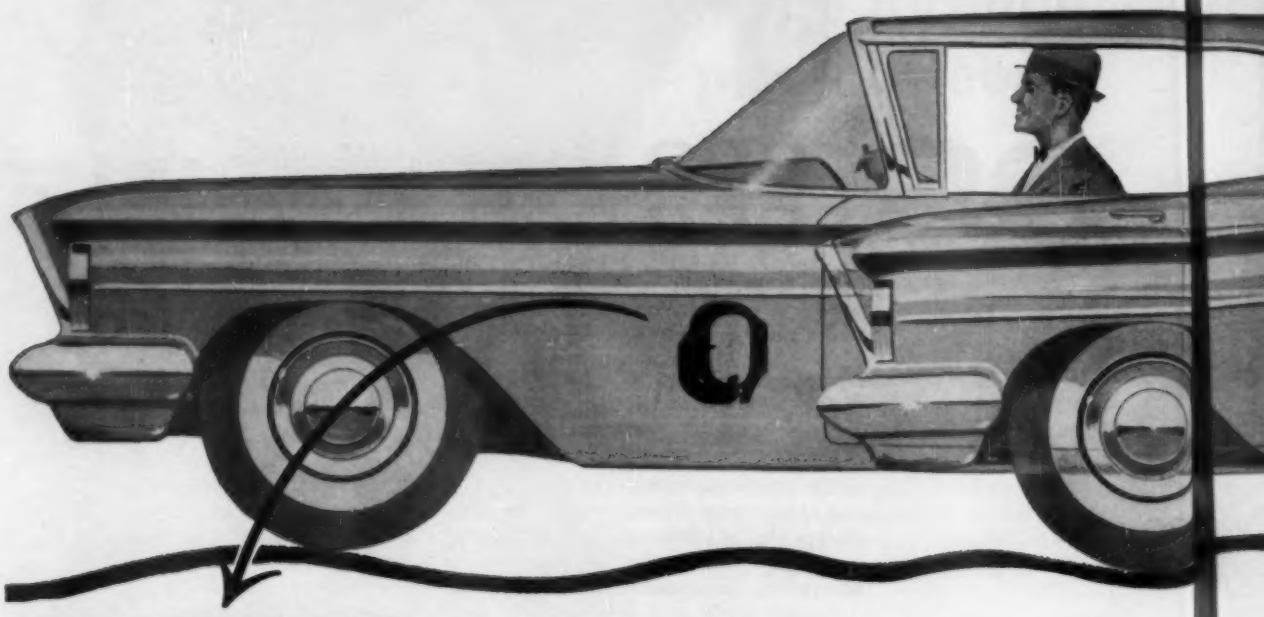
PLASTICS ENGINEERING COMPANY

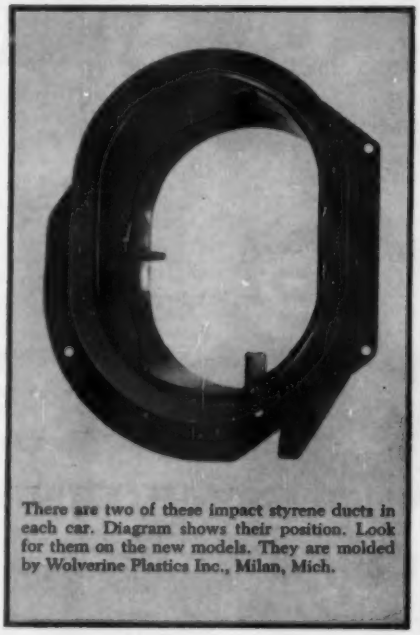
SHEBOYGAN, WISCONSIN

Serving the plastics industry in the manufacture of high grade phenolic molding compounds, industrial resins and coating resins.

IMPACT STYRENE O

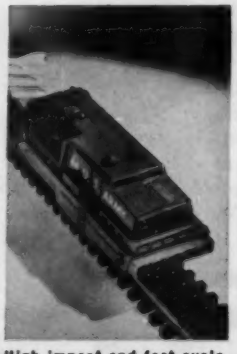
...injection molded air ducts in





There are two of these impact styrene ducts in each car. Diagram shows their position. Look for them on the new models. They are molded by Wolverine Plastics Inc., Milan, Mich.

Other styrenes in this series



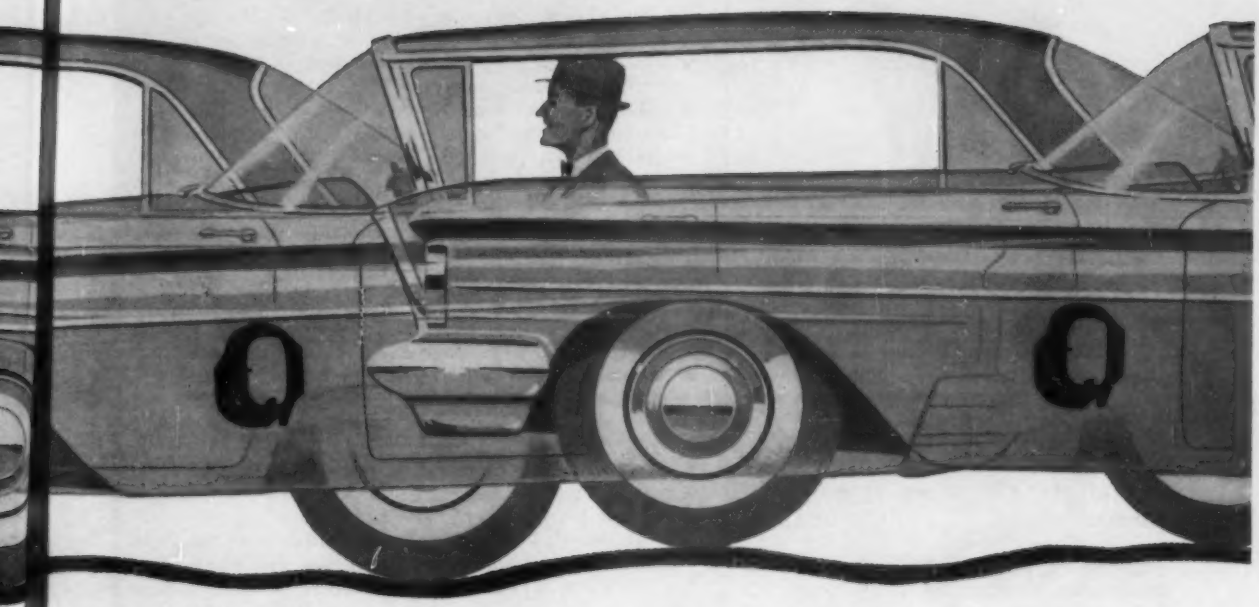
High impact and fast cycle. TMD-6000 is a high impact material for a wide variety of uses—especially where mold filling is critical. It combines set-up speed with plasticity . . . flows easily in large, complex parts, yet sets quickly. (Toy railroad car molded by The Lionel Corporation.)

Medium impact, broad molding latitude. In fact, BAKELITE Brand styrene TMD-9001 is formulated for the widest molding latitude in its class. It is especially good for complex shapes that tax machine capacity. Molded in thin sections, it can be stapled with practically no blushing. (Closures molded by Mack Molding Company, Inc.)

Medium impact and heat resistance. TMD-8000 offers excellent gloss and dry colorability. Production experience indicates that it can be broached without crazing and has high scratch resistance. (Radio cabinet molded for Motorola, Inc. by G. Felsenthal & Sons, Inc.)

E ON THE GO!

ts in Detroit's latest cars



This year's automobiles give impact styrene a tough new job. This air duct has to withstand strain, vibration and heat during both installation and use.

BAKELITE Brand impact styrene TMD-5161 was chosen for its outstanding resistance to both heat and impact—and the molding advantages brought lower costs, faster production. Notice this air duct's intricate design—TMD-5161 is free-flowing enough to fill large complex molds. Rigid but tough, it also takes inserts and self-tapping screws.

TMD-5161 is just one of a series of impact styrenes for injection molding offered by Union Carbide Plastics Company. They are available in a range of impact strengths and heat deflection temperatures. Various formulations offer combinations of properties that should closely fit your needs.

To help in making your choice, the latest issue of MOLDING NEWS, "the Test of Impact," gives plastics fabricators detailed information and suggestions on the use of these materials. Write Dept. LS-02G, Union Carbide Plastics Company, Division of Union Carbide Corporation, 30 E. 42nd Street, New York 17, New York. In Canada, Union Carbide Canada Limited, Toronto 7.

UNION CARBIDE

"BAKELITE" and "UNION CARBIDE" are registered trade marks of Union Carbide Corporation.

SYMBOL OF PROFESSIONAL EMINENCE

New Lapel Pins Available

SPE pins of new design and material can now be obtained from the SPE National Office. The pin is die-molded of zinc in the design shown in the illustration. The SPE red is in baked enamel finish and the letters and margin are provided by the gold of the die casting showing through.

In approving the new material and design, the Membership Committee emphasized that both the plastic pin, distributed previously, and the new die-molded zinc pins are official SPE pins. The zinc pin does *not* supersede the plastic pin.

The new pins are mailed gratis to all new members admitted to the Society since the supply of plastic pins became exhausted.

To Sections and other SPE members they may be purchased postpaid from the SPE National Office, 65 Prospect Street, Stamford, Conn., as follows:

No. of Pins	Price
1-24	$1.00 each
25 and more	.75 each

All orders must contain remittance.

Stability RETEC Book Completes SPE's 1959 Publications

Now Available

★ **NATEC Preprint Book**—Volume I, 1959, Los Angeles, 20 papers. $5.00 members; $7.50 non-members (See program, September SPE Journal, page 788, and Abstracts on pages 815-817).

★ **Stability of Plastics**—Baltimore-Washington Section; Nine 1000-word abstracts, $1.00 members; $1.50 non-members (See program page 897, Oct. SPE Journal).

★ **Plastics in the Shoe Industry**—St. Louis Section, 11 papers, $3.00 members, $4.50 non-members. (See program, September SPE Journal, page 820).

★ **Plastics in Packaging**—Golden Gate Section, 12 papers, $3.00 members; $4.50 non-members. (See program, October SPE Journal, page 899).

OTHER 1959 RETEC PREPRINT BOOKS

★ **Vinyl Plastics**—Cleveland Section, 8 papers. $2.50 members; $3.75, non-members. (See program, SPE Journal, August, 1959 issue, p. 745).

★ **Plastics Finishing**—Buffalo Section, 4 papers, $2.00, members; $3.00 non-members. (See program, SPE Journal, September, 1959 issue, page 823).

★ **Encapsulation, Printed Circuits, and Fluidized Bed Processes**—Northern Indiana Section, 15 of 23 papers presented. $3.00, members; $4.50, non-members. (See program SPE Journal, April, 1959, p. 319).

★ **Plastics in the Automotive Industry**—Detroit Section, 4 papers, $2.00, members; $3.00 non-members. (See program SPE Journal, May, 1959, p. 443).

★ **A Designer's Look at Reinforced Plastics** from the Pleasure Boat, Aircraft and Missile Industries Viewpoint—North Texas Section, 6 papers. $2.00, members; $3.00, non-members. (See program SPE Journal, April, 1959, p. 324).

★ **Plastics in the Metals Industries**—Pittsburgh Section, 10 papers. $3.00, members; $4.50, non-members. (See program SPE Journal, April, 1959, p. 324).

SPE PLASTICS ENGINEERING SERIES

Vol. II—Processing of Thermoplastic Materials, 705 pages. $14.40, members; $18.00, non-members.

Vol. I—Quality Control for Plastics Engineers. $3.98, members; $4.95, non-members.

ANTEC PREPRINT BOOKS

Vol. V, 1959, New York City, 96 papers. $7.50, members; $12.50, non-members. Single preprints of individual papers, Vol. V, while they last, $0.25 each, members; $0.40 each, non-members.

Vol. IV, 1958, Detroit, 94 papers. $5.00, members; $7.50, non-members.

Vol. III, 1957, St. Louis, 60 papers. $5.00, members; $7.50, non-members.

SPI individual members are entitled to SPE members' prices under a reciprocal agreement.

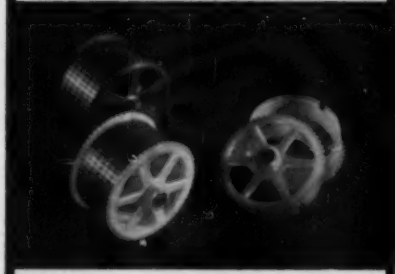
Books will be mailed postpaid if money is enclosed. Please address orders to:

Society of Plastics Engineers, Inc.
65 Prospect Street
Stamford, Conn.

SNAP-ON FASTENERS for accordion-door covers and quiet roller wheels are made of ZYTEL, which provides resiliency and resistance to impact and abrasion. (Molded by Flambeau Plastics Corp., Baraboo, Wis., for Hough Mfg. Corp., Janesville, Wis.)

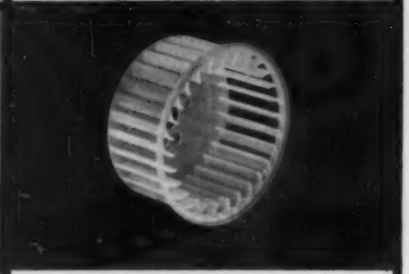
OUTBOARD-MOTOR PROPELLER, made of Du Pont ZYTEL, is tough, durable and noncorrosive even in salt water. It adjusts its pitch automatically. Use of ZYTEL makes possible considerable cost savings. (By Grish Brothers, St. John, Indiana.)

POWER-MOWER THROTTLE is molded of Du Pont ZYTEL 101 in several colors, taking advantage of this resin's toughness, wear resistance, chemical resistance and light weight. (By Western Control Corporation, Wichita, Kansas.)



SPROCKET FOR TIME CLOCK has high strength, high fatigue-endurance limit, light weight. Injection-molded of ZYTEL, it cuts costs, simplifies assembly. (Molded by Hamilton Plastics Molding Co. for Cincinnati Time Recorder Co., both of Cincinnati, O.)

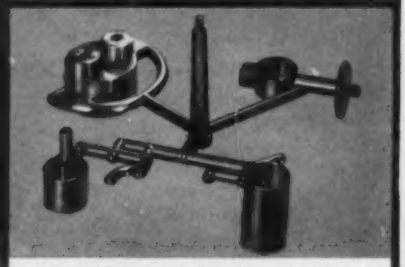
SPINNING REEL operates smoothly, is exceptionally light in weight, easy to handle and durable. Almost all parts are molded of Du Pont ZYTEL. (Molded by Plano Molding Co., Plano, Ill., for Waltco Products Incorporated, Chicago, Illinois.)



"SQUIRREL-CAGE" BLOWER is used in refrigerators. Made of Du Pont ZYTEL, this intricate, thin-walled molding has high strength, and is unaffected by the low temperatures encountered. (By Torrington Manufacturing Co., Torrington, Connecticut.)

SAND SPIKE fishing-rod holder is made of two parts of orange-colored ZYTEL. It is tough, corrosion-resistant and light in weight. (Molded by Du Bois Plastic Products, Inc., Buffalo, New York, for The Gliebe Co., Brooklyn, New York.)

POSTS for loose-leaf binders that hold business records are made of tough, flexible ZYTEL, easily threaded into holes. The posts permit greater sheet capacity, flatter opening than posts of other materials. (By Wilson Jones Co., Chicago, Illinois.)



AIR PUMP for aquarium has molded cap, bushings and cam actuator made of Du Pont ZYTEL. These parts offer high strength and abrasion resistance . . . make possible economies in production. (By Eugene Danner, Brooklyn, New York.)

Design advantages of ZYTEL® nylon resins demonstrated in wide variety of applications

Versatile ZYTEL nylon resins offer the designer a combination of properties that can be used to improve the performance and lower the cost of almost any mechanism. The high strength, abrasion resistance and low friction of ZYTEL make it an outstanding gear and bearing material. It is resistant to heat and chemicals. It can be economically injection-molded in intricate one-piece configurations, with moldings held to close tolerances. The result: reduction in inspection cost, material cost, fabrication cost.

Many molders have the experience to supply you with parts of ZYTEL nylon resin in quantity to your exact specifications. For your copy of a booklet, "Designing with ZYTEL nylon resins", write to: E. I. du Pont de Nemours & Co. (Inc.), Department KK-12, Room 2507Z, Nemours Building, Wilmington 98, Del.

In Canada: Du Pont of Canada Limited, P.O. Box 660, Montreal, Quebec.

POLYCHEMICALS DEPARTMENT

DU PONT

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING. . . *THROUGH CHEMISTRY*

Despite the best of care...

Who hasn't had some troubles with vacuum metallizing?

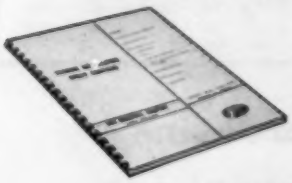
Vacuum Metallizing is the way to big profits, exciting design, fabulous possibilities for the future. But—as with any relatively new process—it sometimes turns up "bugs" that have to be solved.

We've had our share. Because Bee's Logo Division produces a greater variety of coatings for vacuum metallizing, on more materials, for a greater range of end uses, than any other manufacturer.

We've had to come up with solutions to problems involving resinous base coatings used on plastics, metals or glass—each presenting specific production difficulties. Top coatings, clear, opaque or in color, are separate problems. Our answers involve coatings that bake or air dry in minutes, speeding production, increasing capacity, cutting costs.

The point is this: with Logo's variety of *standard* coatings for vacuum metallizing, applied as recommended, most production problems simply vanish. But to the tough ones, Bee's Logo Division brings you a great depth of technical service—the kind that gets problems solved.

Logo Vacuum Metallizing Coatings—and Logo services—can help you.



Here's a new booklet jam-packed with helpful information about vacuum metallizing coatings . . .

Send for it now. Contains complete coating chart for plastics, metals and glass.

A real working tool you will use frequently. Ask for Bulletin *A129*

TRADE MARK

BEE CHEMICAL COMPANY

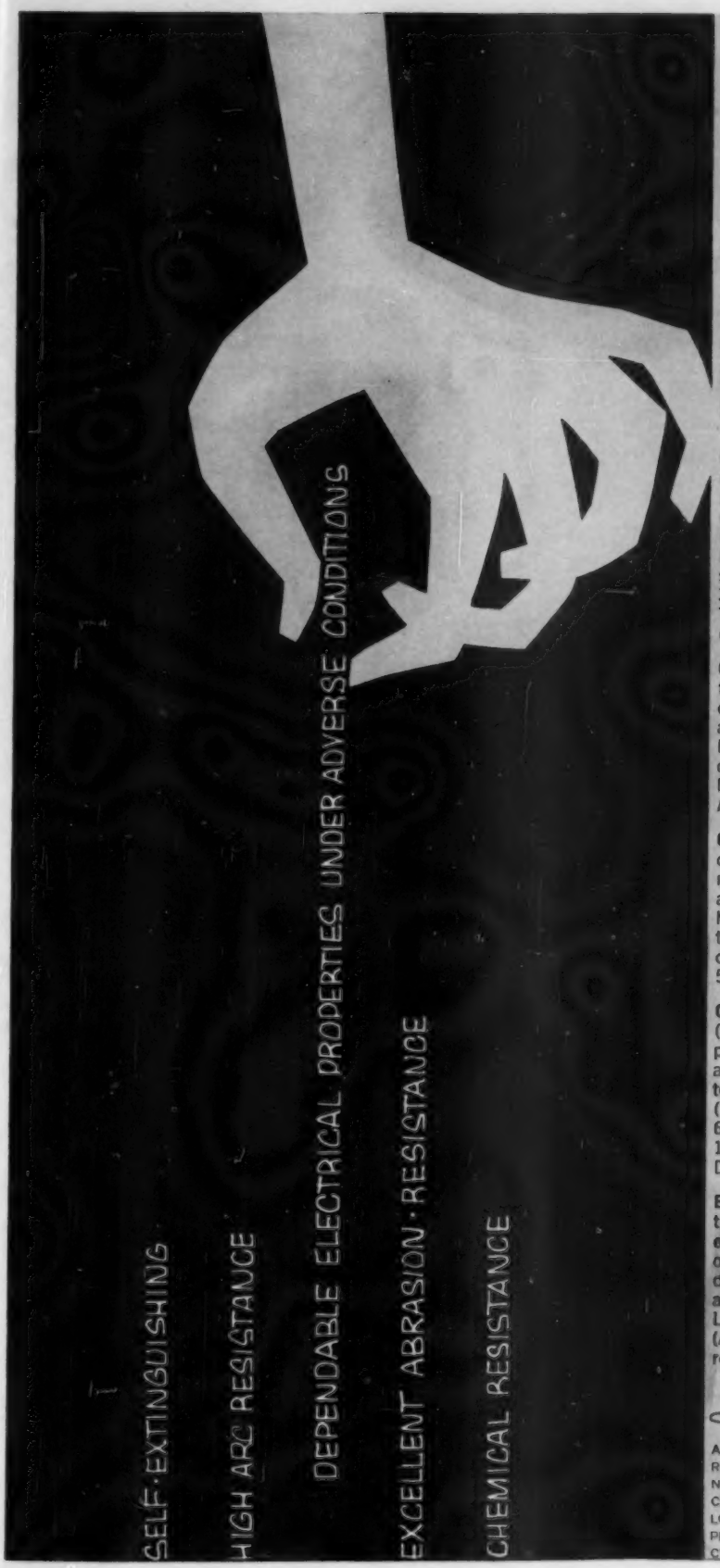
LOGO DIVISION

12933 S. Stony Island Ave., Chicago 33, Illinois
Phone: Mitchell 6-0400

Gardena, California
17000 S. Western Ave.
Phone: DAvis 9-8343

Hartford 3, Connecticut
119 Ann Street
Phone: CHapel 9-7691

Visit our Hospitality Suite, Conrad Hilton
National S.P.E. Technical Meeting
12-15 January—Chicago



CYMEL®
MELAMINE

BEETLE®
UREA

PLASTICS

REMEMBERED FOR PERFORMANCE – CYANAMID MOLDING COMPOUNDS

CYMEL 3135–3136 (glass-filled) Additional distinctive properties: outstanding electrical properties; high impact resistance; extraordinary flame resistance; good dimensional stability. Typical applications: circuit breaker boxes; terminal strips; connectors; coil forms; stand-off insulators. Specifications: Cymel 3135 (MMI-30, MIL-M-14E, Federal L-M-181 Type 8; ASTM D704-55T Type 8); Cymel 3136 (MIL-M-19061, MMI-5).

CYMEL 592 (asbestos-filled) Additional distinctive properties: resistance to atmospheric extremes; high dielectric strength. Typical applications: connector plugs; terminal blocks; a/c, automotive and heavy duty industrial ignition parts. Specifications: MIL-M-14E MME; Federal L-M-181 Type 2; ASTM D704-55T Type 2, SP1 SPEC NO. 27025.

CYMEL 1077 (alpha cellulose-filled) Additional distinctive properties: Surface hardness, heat resistance, unlimited color range. Typical applications: appliance housings, shaver housings, business machine keys. Specifications: MIL-M-14E – Type CMG (in approved colors); Federal L-M-181 Type 1; ASTM D704-55T Type 1, SP1 SPEC NO. 30026.

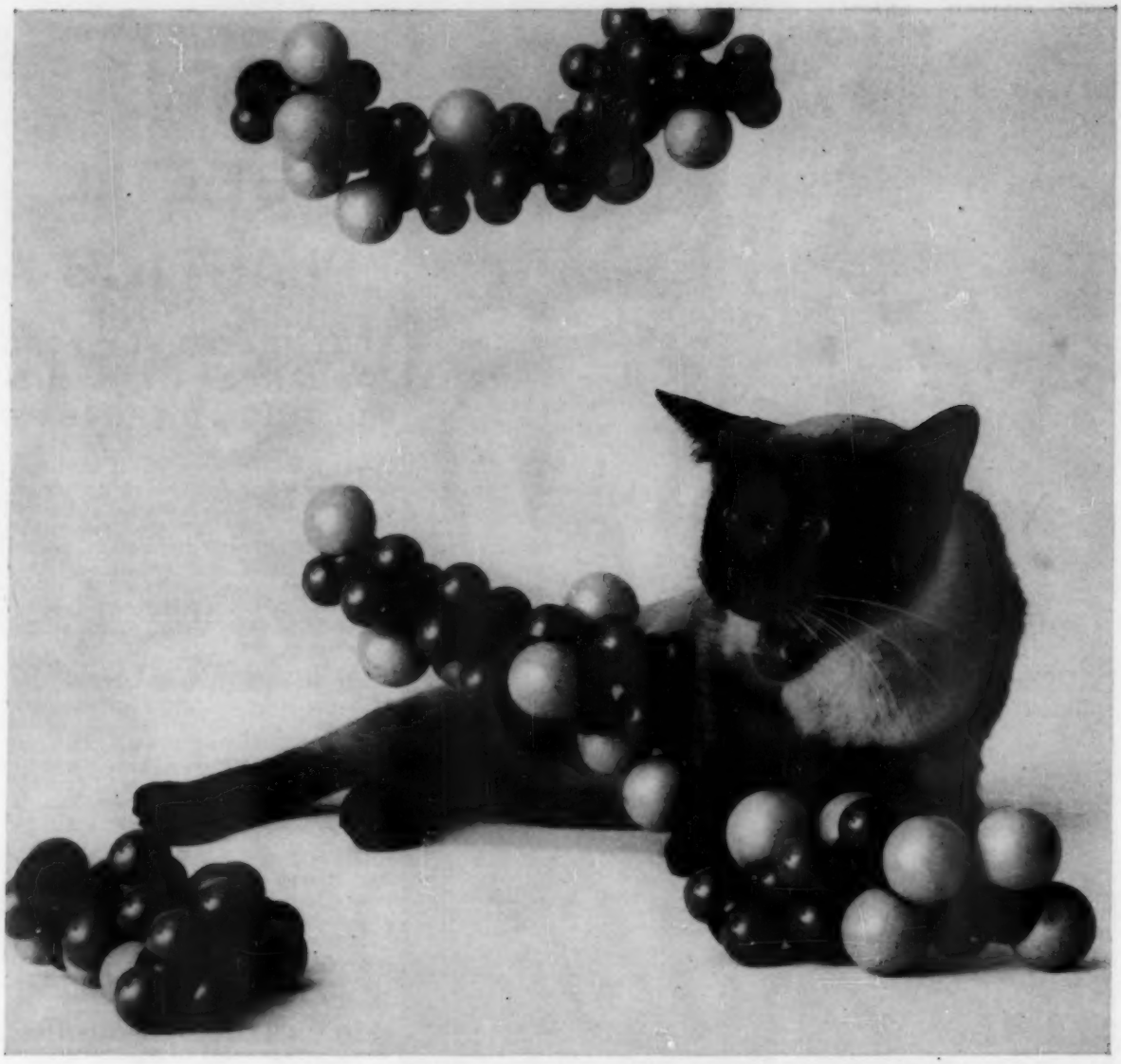
CYMEL 1500 (wood flour-filled)–CYMEL 1502 (alpha cellulose-filled) Additional distinctive properties: Good insert retention. Typical applications: meter blocks, ignition parts, terminal strips. Specifications: Cymel 1500 (MIL-M-14E Type CMG, Federal L-M-181 Type 6, ASTM D704-55T Type 6); Cymel 1502 (MIL-M-14E Type CMG, Federal L-M-181 Type 7; ASTM D704-55T Type 7.

BEETLE® UREA (alpha-filled) Additional distinctive properties: Economy of fabrication, economy of material, myriad translucent and opaque colors. Typical applications: wiring devices, home circuit breakers, tube bases, appliance housings. Specifications: Federal L-P-406A, LC 726-1, ASTM D705-55, Grade 1 (Arc resistance limits are in process of revision by ASTM), SP1 SPEC NO. 27026.

WRITE FOR COMPLETE TECHNICAL DATA.

CYANAMID

AMERICAN CYANAMID COMPANY • PLASTICS AND RESINS DIVISION • 30 ROCKEFELLER PLAZA–NEW YORK 20, N. Y. OFFICES IN: BOSTON • CHARLOTTE CHICAGO • CINCINNATI • CLEVELAND • DALLAS • DETROIT LOS ANGELES • MINNEAPOLIS • NEW YORK • OAKLAND PHILADELPHIA • ST. LOUIS • SEATTLE • IN CANADA: CYANAMID OF CANADA LTD., MONTREAL AND TORONTO.



ARGUS MAKES VINYLS BEHAVE!

Can you control the behavior of vinyls? Argus says "yes."

Continuous, creative research—on vinyl reactions to heat, light, sulphide staining, outdoor weatherability and scores of other tests—gives Argus an intimate knowledge of the behavior of vinyl products *under conditions of actual use*. Thus, we can make your vinyls behave—in processing and in performance—by providing you with Mark stabilizers or Drapex plasticizers to meet your needs.

If, for example, your basic requirement is exceptional heat and light stability, you'll get it consistently, and at less cost, with Argus Mark LL—the most effective vinyl stabilizer on the market today. And for any *special* problems, *Argus gets the answers.*

Why gamble on the quality of your products or on customer satisfaction? Call or write for consultation, technical bulletins, samples.

ARGUS CHEMICAL CORPORATION / New York and Cleveland

Main Office: 633 Court Street, Brooklyn 31, N.Y. Branch: Frederick Building, Cleveland 15, Ohio

Rep's.: H. M. Royal, Inc., 11911 Woodruff Ave., Downey, California; Philipp Bros. Chemicals, Inc., 10 High St., Boston; H. L. Blachford, Ltd., 977 Aqueduct St., Montreal. European Affiliates: SA Argus Chemical NV; 33, Rue d'Anderlecht, Drogenbos, Belgium—Lankro Chemicals, Ltd.; Salters Lane, Eccles, Manchester, England.

SPE Journal Volume 15, Number 12, December, 1959

George R. Rugger, *Picatinny Arsenal, Dover, Del.*

Use of Reground Glass-Filled Polystyrene

Does the use of reground glass-filled polystyrene blended with virgin material affect the strength of items molded from it? Test results reported in this article indicate that it does not—a conclusion of far-reaching effect for economy-minded molders

In molding plastic items for civilian use, sprues, runners, and rejects are frequently ground up and blended with virgin material. Most Military specifications, however, require that 100% virgin material be used. This requirement is justified on the basis that Military items are more likely to be of a critical nature and their failure potentially much more hazardous. If reground material could be used in some Military applications, savings would be considerable.

The question as to whether or not reground material could be used became very important in connection with a program for the procurement of nonmetallic mines made of glass-filled polystyrene. At the suggestion of Victory Plastics Company, Hudson, Massachusetts, the program discussed in this paper was initiated. These mines are purchased under Ordnance Ammunition Command Purchase Description Number 25 (Mine, Anti-Tank, Nonmetallic M-19, Parts for). A picture of the M-19 mine is shown in *Figure 1*. In the manufacture of this mine, the savings which could result from the use of reground material was larger than for many other items. This potential saving was based on the magnitude of the program, the relative expense of the molding material as compared with many other plastic materials, and the lack of a civilian market for the scrap produced. Hence, it was decided to determine the effect of incorporating 10%, 20%, and 30% reground scrap into the material from which the mines were to be molded on the acceptability of such mines. Since the mold design was such that nearly 20% of the material was in the form of runners and sprues, the incorporation of 30% scrap would make it possible to use up the accumulation of scrap from previous runs in addition to that currently produced.

Program

Acceptance of the molded mine is primarily based upon its ability to withstand a drop test. The item specification states that mines shall be loaded with simulated explosive and be conditioned for 48 hours, 16 mines at −65° ± 2°F and 16 at 160° ± 2°F. While still at the conditioning temperature they are dropped from a height of four feet onto a solid concrete pad. Each mine is dropped three times so as to hit once on the bottom, once on a side, and once on the top. The mine fails to pass the test if it breaks and cracks to the point where it will no longer function properly. This same drop test was used as the main criterion for the acceptability of mines made from material containing reground scrap.

The mines containing reground material were molded by private contractors, designated in *Table I* as Molders A and B. In addition, test specimens were molded at Picatinny Arsenal of (1) the virgin material from the two manufacturers (listed in *Table I* as Manufacturer A and Manufacturer B) of the molding compound, (2) the reground scrap from the two molders, and (3) blended materials which were the same as that which went into the mines. These specimens were used to determine which laboratory tests, if any, would predict acceptability. The tests which were run were tensile strength, Izod impact strength, relative viscosity of the resin binder, deformation under load, Rockwell M hardness, and percent glass.

The laboratory tests used were chosen because:

Tensile strength is affected by fiber length. Thus, if fiber breakage occurred in the grinding process, this test should detect it.

The Izod impact test most closely simulates the drop test.

The relative viscosity test would reflect molecular weight degradation of the resin binder.

The deformation under load and the Rockwell M hardness tests reflect the ability of the compound to deform.

Any loss of either glass or the resin would result in a change in the percent glass content.

Figure 1. Polystyrene anti-tank mine.

Procedure

Virgin glass-filled polystyrene molding materials were obtained from two manufacturers (A and B). Materials obtained from Manufacturer B included both the older, weaker, material and the newer, stronger material. A material in which 25% of the resin was a modified polystyrene as distinct from normal polystyrene was also obtained from Manufacturer B. Coarse and fine reground scrap and blends of 10, 20, and 30% coarse reground scrap combined with virgin material were obtained from Molders A and B. These materials were molded into test specimens and tested. The "coarse" material was obtained from a scrap grinder containing 1½ inch screen while the "fine" material was obtained using a 1 inch screen in the grinder.

The specimens were molded on a 1-oz Watson-Stillman injection machine. The mold block size precluded the molding of the standard ASTM D-638 Type I specimen on this machine so a non-standard tensile specimen (*Figure 2*) was molded.

The tensile tests were run on a Tinius Olsen Plastiversal Tester using a crosshead speed of 0.2 inches per minute. The impact tests were run on a Baldwin Southwark pendulum-type machine based on the Bell Telephone Laboratory design. A one foot-pound hammer was used and each ⅛ inch thick specimen was tested individually. Both the impact and tensile tests were conducted at 23 ± 1°C and 50 ± 2% R.H. after a minimum of 48 hours at the same conditions.

Deformation under load tests were run in accordance with Method 1101 of LP-406. The test temperature was maintained at 50 ± .5°C and a force of 4,000 psi applied. The ⅛ inch thick specimens were obtained by stacking four ¼ inch pieces.

The Rockwell M values were obtained using a Model 4 JR-P1 tester in accordance with Method 1081.1 of LP-406

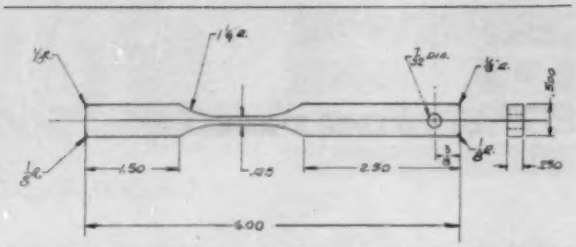


Figure 2. Standard tensile specimen tolerance on all dimensions, plus or minus .005 inches.

The relative viscosities were obtained by running 1% solutions in benzene.

Results

The results of the testing are shown in *Table I*. The blank spaces indicate that tests for a particular material were not run. In some cases tests were omitted because of the extra expense incurred by molding of mines and in other cases, because if no change occurred among the virgin and the reground materials, blends of the two would not be expected to reflect changes.

This table shows that mines made of material incorporating reground scrap successfully passed the drop tests. This achieved the primary objective of this work. The secondary objective of relating laboratory tests to end item suitability was also accomplished for this specific item. High values of tensile strength and Rockwell M hardness correlated with the ability of the T-19 mine to pass the drop test. The Izod impact and the deformation under load tests did not correlate with the acceptability of mines molded from this material and were actually misleading. The single grinding changed neither the glass content nor the molecular weight of the resin as determined by viscosity measurements.

Table I. Effect of Grinding & Blending on Selected Properties of Glass-filled Polystyrene

Mfg.	Mat'l	Ult.* Tensile Strength psi	Coef. of Variation Tensile Test	Impact Strength ft-lbs/inch	Coef. of Variation Impact Test	Relative Viscosity deci-liters/gm	Deformation Under Load %	Rockwell M Hardness	% Glass	Drop Test Results
A	Virgin	17,100 (13,000)	5.8	1.76	15.3	.47	.73	93	35.34	Several lots passed
A	Coarse Ground from Molder A	13,000	8.9	.76	11.8	.44	1.38	85	35.16	—
A	Fine Ground from Molder A	12,900	5.0	.87	9.2	—	1.07	86	—	—
A	10% Coarse 90% Virgin from Molder A	15,800	1.5	1.83	25.1	—	—	91	—	Passed
A	20% Coarse 80% Virgin from Molder A	15,400	4.1	1.98	18.9	—	—	92	—	Passed
A	30% Coarse 70% Virgin from Molder A	13,700	5.5	1.54	5.2	.44	1.28	91	35.51	Passed
A	Ground, Retained on 3/16" Screen from Molder A	13,500	2.5	1.00	9.0	—	—	85	—	—
B	Older Material	11,300 (8,580)	6.0	2.12	12.3	—	.35	78	38.67	Rejected, 6 of 36 failed
B	Newer Material	14,200 (12,900)	6.3	1.83	14.8	—	.51	90	37.05	Passed
B	Newer Mat'l with 25% Modified PS	10,100 (8,670)	7.6	2.17	11.5	—	.52	74	35.76	Rejected, 8 of 31 failed
A	Coarse Ground from Molder B	13,400	3.4	.96	11.4	—	—	83	—	—
A	30% Coarse 70% Virgin from Molder B	14,600	6.8	—	—	—	—	—	—	—

*Values in parentheses obtained on Standard ASTM D-638 Specimens (Type I, ⅛ inch thick).

The Specific Heat of High Polymers

The specific heat, Cp, of a number of thermoplastic and thermosetting polymers has been determined over the temperature range 30°C. to 160°C. The Cp vs. temperature data are of great interest, particularly in the range of their second order transition temperature, Tg, which is important because of the relationship to mechanical and electrical properties of polymers.

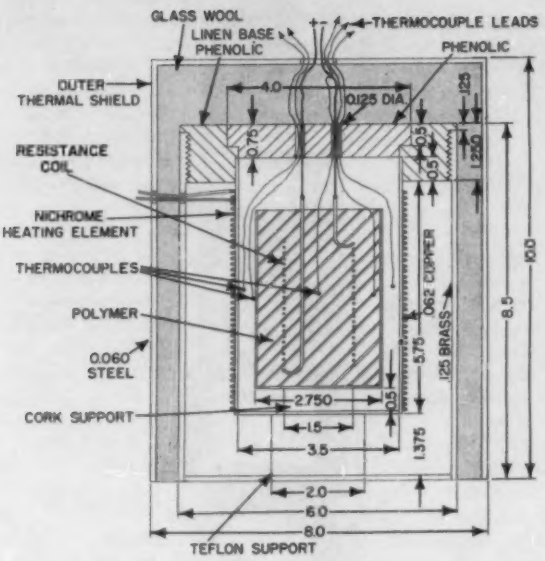


Figure 1. Cutaway drawing shows adiabatic calorimeter used in determining specific heats of high polymers. Calorimeter consists of three concentric cylinders, the two inner cylinders being nickel plated to minimize radiation losses.

R. W. Warfield, M. C. Petree and P. Donovan
U. S. Naval Ordnance Laboratory, White Oak, Silver Spring, Md.

A knowledge of the specific heat, Cp, of high polymers is becoming increasingly important since the use of thermoplastic and thermosetting polymers is rapidly increasing. Unfortunately only a relatively small amount of accurate Cp data, determined as a function of temperature, are presently available, and almost all of these data are on thermoplastic polymers. Most of these data have been obtained by Dole and co-workers (9) and by Ueberreiter (10). The thermosetting polymers have not received much study in the past, and their Cp vs. temperature data are of considerable interest, particularly in the range of their second order transition temperature, Tg. The determination and study of these transitions are of great importance because of their relationship to the mechanical and electrical properties of the polymer.

From accurate Cp data determined as a function of temperature it is possible to determine not only the magnitude of the Cp and its temperature dependence, but with many thermoplastic polymers, the crystallinity, the melting point (Tm), and the heat of fusion can also be established. In both thermoplastic and thermosetting polymers the temperature range and the magnitude of the second order transition can be determined. Also the Cp data can be used together with other experimental data to calculate thermal diffusivity and heat of polymerization. The observed Cp values are a fundamental property of the polymer and depend upon the natural frequencies and amplitudes of vibration of groups of atoms within the polymer. The determination of melting points and second order transitions by calorimetric techniques is one of the most accurate and fundamental methods available.

Presented in this paper are data on the Cp as a function of temperature for a number of thermoplastic and thermosetting polymers. Also presented are data on the melting point and second order transition range of these polymers.

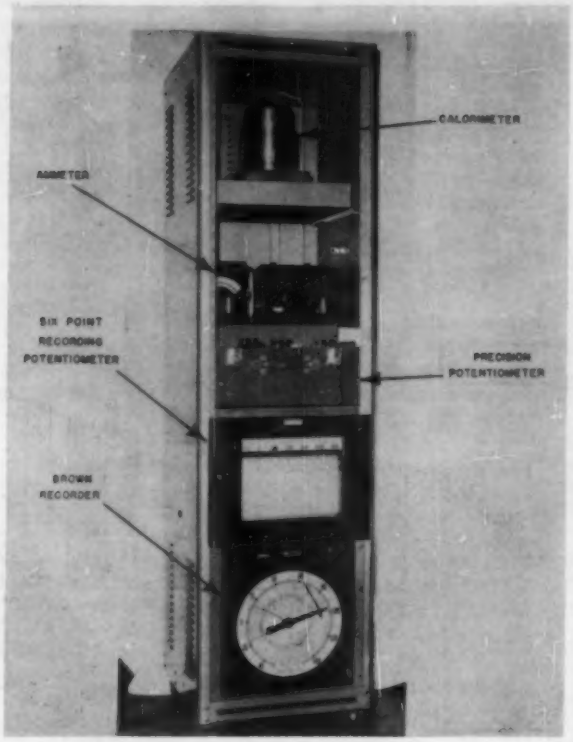


Figure 2. Adiabatic, calorimeter.

The adiabatic calorimeter which was developed to determine these values is also briefly described.

Calorimeter and Experimental Technique.

An adiabatic calorimeter was constructed for determining the Cp of polymers over the range 30°C to 160°C. The essential features of this instrument are shown in *Figure 1*. It consists of three concentric cylinders, the two inner cylinders being nickel plated to minimize radiation losses. Inside the innermost cylinder is the calorimeter vessel which consists of a 325cc No. 1 size can containing the polymer sample. The adiabatic jacket (innermost cylinder) of the calorimeter is lightly wrapped with asbestos cloth, over which is wound a 200 watt resistance coil. This jacket is heated by alternating current and is automatically maintained at the same temperature as the polymer sample by a Brown potentiometer control circuit. Actuation of the control circuit is accomplished by the resultant E.M.F. from two differentially connected thermocouples, one taped on the inner wall of the adiabatic jacket, the other on the calorimeter vessel. An auto transformer is incorporated into the circuit for fine control. Five recording thermocouples are placed at different points on both the inner wall of the adiabatic jacket and on the calorimeter vessel. Any departure from adiabatic conditions can thus be promptly detected. The temperature at the midpoint of the axis of the cyclindrical polymer is measured every 300 seconds with a precision potentiometer (Leeds and Northrup No. 8662). Simultaneous temperatures at all these points are maintained within 1°C.

The polymer sample is heated by passing 1.5 ampere direct current through a previously embedded 2.4 ohm resistance coil. Power input is continuous and approximately constant. The resistance of the heating coil is measured as a function of temperature by a Wheatstone bridge, and the current is continuously measured by a precision ammeter. The heating rate initially is about 1°C per 100 seconds, but decreases slightly with increasing temperature. The temperature rise in the polymer sample is determined by the precision potentiometer. A reference junction is used which is maintained at 0°C.

It will be observed in *Figure 1* that a second thermocouple is placed in the polymer close to the outside of the sample. This is a precautionary measure to detect any thermal gradients. Under experimental conditions the heat is developed so slowly in the polymer sample that the temperature of the entire mass rises at a uniform rate. This lack of thermal gradients has been verified many times by thermocouples embedded at different places in the polymer samples.

Since polymerization must be complete before a Cp determination is made, the thermosetting polymers were polymerized in the calorimeter vessel at a temperature higher than that to be reached during the subsequent Cp determination. The thermoplastic polymers were melted into the calorimeter vessel and cooled very slowly to anneal the polymer.

The calorimeter can be used to study the Cp and transitions of any polymer that can be polymerized, melted or molded around the resistance coil in the calorimeter vessel. Powdered samples of both filled and unfilled polymers can also be studied. A typical Cp determination over the range 30°C to 160°C requires about 8 hours.

At the time this work was conducted there were no Cp data available on these polymers which could be used to determine the energy equivalent of the calorimeter. Therefore, fused succinic acid was used as a primary standard to determine this correction as a function of temperature. The Cp of succinic acid is given as 0.248 plus 0.00154 T over the range 0°C to 160°C (4). Its Cp when determined in the NOL calorimeter was found to be 0.253 plus 0.00174 T. The difference (0.005 plus 0.00020 T) is the correction, which must be subtracted from a measured Cp value. T represents the average temperature over the time interval considered. The accuracy of this instrument is estimated to be about 2%.

The average Cp for each temperature increment (usually about 3°C) was calculated from the equation

$$Cp = \frac{I^2Rt}{JM(\Delta T)}$$

where I is the current, R is the resistance of the heating coil, M is the mass of the polymer, ΔT is the rise in temperature in the time interval t, and J is the mechanical equivalent of heat. The calorimeter is shown in *Figure 2* with the outer thermal shield removed. A brief description of the calorimetric technique used in this study has been previously published (1).

Results.

During the course of this work, Wunderlich and Dole presented data on the Cp of low pressure polyethylene (Marlex 50, Phillips Petroleum Co.). This polymer has thermal properties very similar to many other thermoplastic and thermosetting polymers and it was decided to use this polymer as a secondary standard to check the accuracy of the calorimeter as well as the energy equivalent. The Cp of this polymer is shown in *Figure 3* together with the results of Wunderlich and Dole. It will be noted that results obtained with the NOL adiabatic calorimeter are superimposable with those obtained by Wunderlich and Dole not only at the lower temperatures but through the melting range, which is complete at about 134°C, and into the liquid phase.

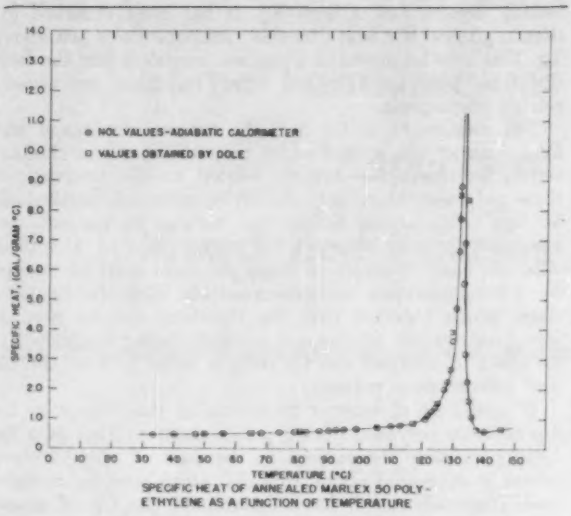

NOL VALUES-ADIABATIC CALORIMETER
VALUES OBTAINED BY DOLE
SPECIFIC HEAT, (CAL/GRAM °C)
TEMPERATURE (°C)
SPECIFIC HEAT OF ANNEALED MARLEX 50 POLY-
ETHYLENE AS A FUNCTION OF TEMPERATURE

Figure 3. Specific heat of annealed marlex 50 polyethylene as a function of temperature.

A further check on the instrument was made by Cp determinations on polystyrene over the temperature range 30°C to 140°C. These results were compared with those of Ueberreiter and Otto-Laupenmuhlen (10), and good agreement was obtained with their results on polystyrene up to and through the second order transition. This transition, which starts at 81°C, was clearly resolved by this calorimeter. Thus, this instrument can be used to determine not only the Cp of polymers in the range 30°C to 160°C with a high degree of accuracy but also second order transitions and melting points, if present. Additional results with thermosetting polymers are shown in *Figures 5, 6,* and *7.*

Discussion

It has been recognized for some time that the properties of polyethylene are to a great extent dependent upon the manner in which the polymerization was conducted. Therefore, it would be expected that Cp vs. temperature plots for different types of polyethylene would exhibit differences. In *Figure 4,* the Cp's of three types of polyethylene are shown. Epolene C (Eastman Corp.) is made by a special low pressure process and is characterized by a very low average molecular weight and also by low melt viscosity. This polymer exhibits a higher Cp over the same temperature range than the two other polyethylenes studied. The higher Cp may be explained, at least in part, by the work of Wunderlich and Dole (9), who have shown that the Cp of a polymer will usually decrease with an increase in molecular weight. The melting point of Epolene C was found to be about 100°C which is in good agreement with Eastman's value (3).

It will be noted in *Figure 4* that the Cp curve of conventional or high pressure polyethylene (Bakelite DYLT, Bakelite Corp.) reveals a melting point of about 104°C. This is in general agreement with published values. At the lower temperatures the Cp of both the high and low pressure (Marlex 50) polyethylene is approximately the same. However, as the temperature is increased and the melting points are approached, the Cp values differ. These two polymers also differ in the amount of crystallinity. At 25°C annealed Marlex 50 is about 90% crystalline while the Bakelite DYLT is about 60% crystalline (9).

The Cp of polystyrene is shown in *Figure 4.* It will be noted that the Cp of this polymer slowly increases up to about 81°C when a second order transition occurs. This transition is complete at about 90°C and the increase in Cp again becomes approximately linear with temperature.

It is of interest to note the relative accuracy with which the melting points of the different types of polyethylene may be determined by this technique. Dole and Wunderlich (2) have recently pointed out that the melting point of Marlex 50 should be determinable with a high degree of accuracy while that of low density polyethylene should be determinable with less accuracy. Thermodynamically, the melting point is defined as the temperature at which liquid and solid polymer are in equilibrium. At this point the Cp vs. temperature plots exhibit a maximum value, and it is this temperature which is taken as the melting point. Thus, the Tm of Marlex 50 has been determined by taking the midpoint of the maximum values of the Cp vs temperature plot during the melting range as the melting point. This can be seen by inspection of *Figure 3.* In the case of the conventional polyethylene (Bakelite DYLT) a larger discontinuity occurs during the melting range than in the case of Marlex 50. Also, the Cp vs. temperature peak is lower and broader, and Tm is thus more difficult to determine accurately. Over the melting range no data points could be obtained because of the lack of a steady state within the melting polymer. The case of Epolene C appears to be intermediate, the melting range being about 3°C. These data suggest that the Cp technique may be a very accurate method for determining the melting points of thermoplastic polymers. Additional work in this field seems to be warranted. The area under the Cp vs. temperature plots in the melting range of the polymer can be used to estimate the heat of fusion of these polymers.

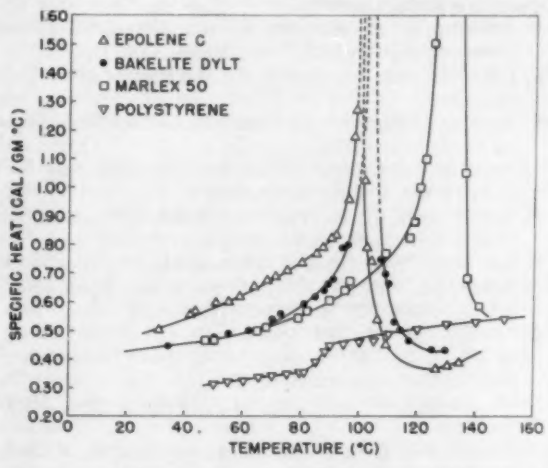


Figure 4. Specific heat of thermoplastic polymers.

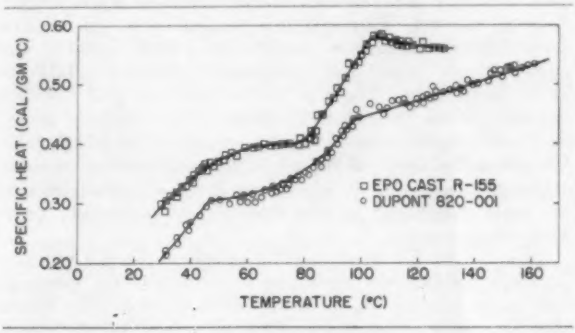


Figure 5. Specific heat of two epoxide thermosetting polymers.

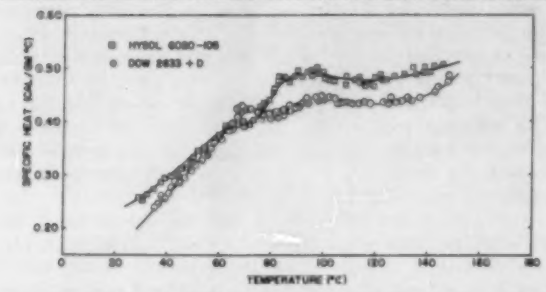


Figure 6. Specific heat of two epoxide thermosetting polymers.

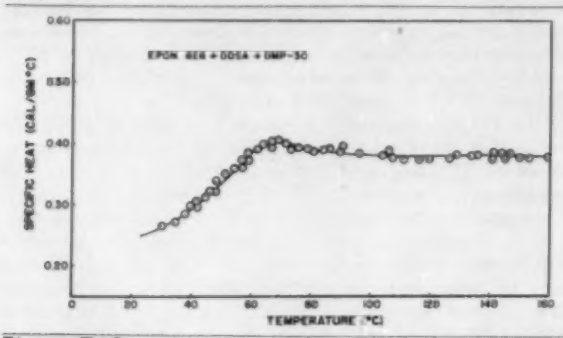


Figure 7. Specific heat of an epoxide thermosetting polymer.

The Cp vs. temperature plots for a number of thermosetting polymers are shown in *Figures 5, 6,* and *7*. All five of these epoxide polymers exhibit definite second order transitions occurring over a relatively broad temperature range, and the manner in which these polymers pass through the transition range is of interest. For example, in *Figure 5* the Cp of Epocast R-155 (Furane Plastics Corp.) is shown. This amine polymerized epoxide exhibits a second order transition which is complete at about 105°C. DuPont 820-001, an amine polymerized epoxide which contains about 20% of an SiO_2 filler, exhibits a transition which is complete at 98°C. While both of these polymers exhibit a broad Tg, the Epocast R-155 shows a much greater increase in Cp as it passes through the transition range.

Both the Hysol 6020-105 (Houghton Laboratories), an amine polymerized epoxide which contains 32% of an SiO_2 filler, and Dow 2633 (Dow Chemical Co.), which is an epoxide polymerized with 10% of tris(dimethylaminomethyl) phenol tri 2-ethyl hexoate(D), exhibit Cp vs. temperature plots of approximately the same type. However, an inspection of *Figure 6* will show that the transitions are complete at temperatures less than 100°C. The Cp vs. temperature plot for Epon 828 (Shell Chemical Corp.) shown in *Figure 7* is of interest. This epoxide polymer was polymerized with 59% of dodecenyl succinic anhydride (DDSA) and about 1% of tris(dimethylaminomethyl)phenol (DMP-30) as an accelerator. The Cp vs. temperature plot for this polymer shows the entire Tg range. This transition occurs in a very smooth manner and is complete by 75°C. This has been the only acid anhydride polymerized epoxide system studied, so it is not known if the smooth transition of small magnitude is characteristic of anhydride polymerized systems.

In a few of the thermosetting polymers the Cp vs. temperature plots do not show any transitions in the temperature range studied (8). In these polymers it can be shown that Tg occurs either below 30°C or above 160°C. This is especially true for polymers intended for high temperature applications, which are characterized by a high crosslinking density and a high Tg. It has been observed (8) that in general the heat distortion temperature is just above Tg. This is to be expected when one considers that the heat distortion point and second order transition are closely related phenomena.

The differences in Cp and the temperature range and magnitude of the second order transition in these thermosetting polymers are directly related to the structure of these polymers. More data should be obtained, particularly at low temperatures before the various components responsible for the observed Cp values can be identified. Also the basic structure of these polymers must be studied by other techniques to make available other fundamental data, which together with the Cp data, can be used in structural studies. Studies are currently being conducted in an effort to interpret the Cp data in terms of heat content and differences in entropy.

It would be of interest to determine the change in the Cp of these polymers during polymerization. This ΔCp has been previously determined in the case of vinyl acetate, where it decreased about 15% (5). More recently Sochava and Trapeznikova (6) have determined the Cp of monomeric methylmethacrylate and polymethylmethacrylate over the temperature range 50°K to 200°K. It was observed that the Cp decreases about 25% upon polymerization. The present apparatus could be used to determine the Cp of liquid monomers. This type of information would be particularly useful in calculating the heat of polymerization of polymers by means of differential thermal analysis (DTA).

Summary

The determination of second order transitions by the Cp method is perhaps the most fundamental and accurate method available. However, determinations made by this method are very time consuming, and a need exists for a more rapid method. A method employing electrical resistivity techniques has been developed, and the results for Tg found by this new method have correlated well with those found by Cp determinations. A detailed description of this method has been previously published (7). It has been noted from the results obtained by both methods that, in general, crosslinked polymers exhibit higher transition temperatures than linear polymers. This is to be expected since the second order transition temperature closely approximates the onset of segmental motion in the polymer chain. Crosslinking tends to restrict this chain motion, hence, the transition temperature of crosslinked polymers is usually higher than that of linear polymers.

Literature References

1. Aukward, J. A. Warfield, R. W., Petree, M. C. and Donovan, P., Rev. Sci. Inst., 30,597 (1959).
2. Dole, M., and Wunderlich, B., Makromol Chem. To be published.
3. Eastman Chemical Products, Inc., Technical Report on Epolene C (1959).
4. *International Critical Tables*, McGraw-Hill, New York, N. Y., 1929, Volume 5, pp. 102.
5. Schildknecht, C. E., *Vinyl and Related Polymers*, John Wiley, New York, N. Y., 1952, pp. 327-336.
6. Sochava, I. V., and Trapeznikova, O. D., Vestnik Leningrad Univ., 13, No. 16, Ser. Fiz. i Khim., No. 3, 65-72 (1958), C. A., 53, 4881 (1959).
7. Warfield, R. W., *SPE Journal, 15*, 625 (1959).
8. Warfield, R. W., Petree, M. C., and Donovan, P., NAVORD Report 6255 (1959).
9. Wunderlich, B., and Dole, M., *J. Polymer Sci., 24*, 201 (1957).
10. Ueberreiter, K., and Otto-Laupenmuhlen, E., Z. Naturforschg, *8A*, 664 (1953).

Some Fundamental Aspects of Fluidized Bed Coating

There is great current interest in fluidized bed coating processes. This article describes three coating techniques and the factors responsible for variable coatings. Also discussed: Safety precautions in handling and using flammable powders.

Joseph Gaynor
General Electric Co.

Dipping, spraying, brushing and extrusion are the classical methods of applying coatings. More recently, such methods as flow coating, electrostatic spraying, electrophoresis, and the use of a fluidized bed have been used. Where advantageous, they have replaced the older coating processes. The coating process discussed herein is the use of a fluidized bed. In one application of this process a coating is applied by heating the substrate to a temperature above the melting point of the coating material and then dipping it into the fluidized bed. Particles which strike the substrate surface fuse and adhere. One description of this process is by Gemmer (7). In examining the literature, it is interesting to note that the idea of using gaseous dispersions of particles as coating media was conceived about 65 years ago.

Other possible coating techniques in conjunction with fluidized systems, not discussed by Gemmer, include electrostatically charged particles or a thin tacky undercoating. Both techniques eliminate the need to pre-heat the part and reduce masking problems. All three techniques will be discussed in some detail.

Proponents of this new process claim it has apparent advantages, such as no solvents, ability to coat complex geometries, one pass, thick or thin coatings, efficient utilization of material (theoretically 100%), high coating rate, simple and inexpensive process equipment, easily automated process, smooth continuous coatings. While the process is simple, an analysis of the number of physical phenomena which take place and their complexities, is anything but simple.

Fluidization phenomena, although reasonably well explored, have not yet been completely explained. If the piece to be coated is preheated, such problems as heat and momentum transfer, melting rate, melt viscosity, and surface tension of the melt, must be considered. If a cold part is used, electrostatic considerations or those associated with coating in liquids as well as tack must be taken into account together with all the problems cited above except heat transfer in fluidized systems. General problems such as adhesion, uniformity, and pinholing, are still present. The usual precautions with respect to clean surfaces are still necessary. Desired properties still depend on material composition. Formulation problems are different and may be somewhat more difficult. In order to assess more precisely how some of the phenomena just mentioned fit into this overall coating process, it would be well to discuss fluidization itself, the three coating techniques, and some safety problems which go hand in hand with the process.

Fluidization—Gas-Solids Systems

Imagine a gas passing upward through a vertical column containing relatively finely divided particles such that gas flow is uniformly distributed over the entire cross-section of the column. At some superficial gas velocity, the weight of the particles will be slightly exceeded by the buoyant force of the gas. At this point, the entire system will assume the apparent properties of a boiling liquid. Although such properties as surface tension, viscosity and even miscibility (6) have been determined for fluidized systems, the analogy is incomplete. *Figure 1* demonstrates various types of phenomena encountered in the fluidization of solids. In liquid

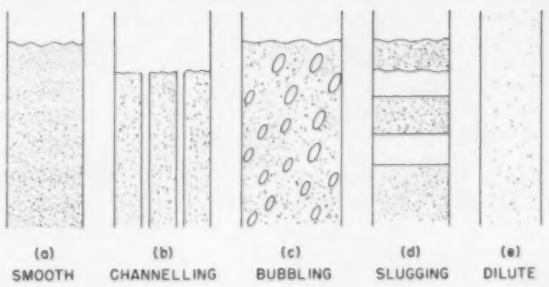


Figure 1—Types of fluidzation. (a) A uniformly fluidized solid. (b) Channelling, instead of uniformly lifting the solid particles, the gas burrows a path along the length of the column and bypasses the powder. (c) Bubbling, gas pockets form in the body of the bed and tend to produce an inhomogeneous system. (d) Slugging—condition results in minimum homogeneity and is an unstable condition. (e) Dilute phase fluidization, although the system is homogeneous, particle concentration is low and a steady state static equilibrium is precluded.

systems, the smoothest and most uniform coatings are obtained in quiescent, homogeneous solutions. On this basis alone, it appears that smooth fluidization, *Figure 1* (a), is most desirable for coating purposes. Further analysis, substantiates the foregoing hypothesis. The ability to attain smooth fluidization over reasonably broad bed expansion ranges depends on the proper balance of such parameters as particle size, particle size distribution, flow character of the powder, gas velocity, humidity, ratio of height to diameter, and pore size and pore volume of distributor plate. The discussion which follows is a brief review of some of the quantitative aspects of fluidization.

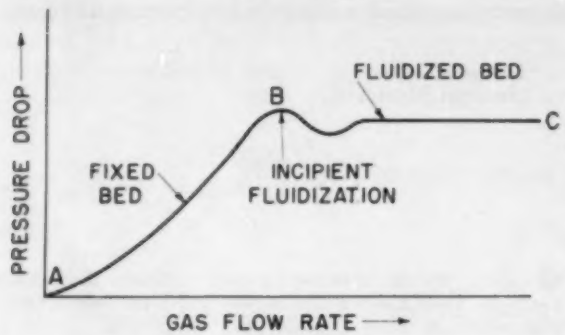


Figure 2. Total pressure drop vs. fluid flow rate

As a gas passes through a bed of particles, the pressure drop increases. At the gas velocity which changes the system from a packed to a fluidized state, the pressure drop no longer increases but approximates a rather shallow sine wave, one wavelength long, and then remains relatively constant. The series of events just described are shown graphically in *Figure 2*. Point B corresponds to the onset of fluidization. The velocity at B is called the "minimum fluidization velocity". Parent, Yagol and Steiner (17) who performed some of the earliest quantitative work in this area showed that the line B-C can be represented mathematically as:

$$\Delta p = L\,(1-\epsilon)\quad (p_p - p_f) \tag{1}$$

To a very close approximation (1) may be rewritten as:

$$\Delta p = \frac{W_s}{A}(1-\epsilon) \tag{2}$$

Ergun (4) accounting for both viscous and kinetic energy losses, proposed the following equation:

$$(\Delta p/L)g_c = 150\,\frac{(1-\epsilon)^2}{\epsilon^3}\cdot\frac{\mu\, u}{d_p^2} + 1.75\,\frac{(1-\epsilon)}{\epsilon^3}\,\frac{Gu}{d_p} \tag{3}$$

The first term represents viscous energy losses and the second term, kinetic energy losses. Experimental data agree better with equation (3) than with equations (1) or (2). Curve A-B is derivable with reasonable precision from the Carman-Kozeny (5) equation for pressure drop in packed beds:

$$f = \frac{g_c\, d_p\, \Delta p\, \epsilon^3}{2L\rho_f\, u^2 (1-\epsilon)^2} = \frac{\phi\, d_p\, u\, \rho_f}{\mu} \tag{4}$$

For non-spherical particles the shape factor Ψ multiplies d_p. Ψ is equal to the surface area of a sphere of the same volume as the particles divided by the surface area of the particle.

Based on equations (1) and (4) Leva et al (13) developed an expression for the minimum mass velocity to initiate fluidization,

$$G = \frac{0.005\, d_p^2\, \epsilon^3\, (\rho_p - \rho_f)\, \rho_f g}{\Psi^2\,(1-\epsilon)\,\mu} \tag{5}$$

Miller and Logwinuk (14) derived an empirical relation for minimum mass velocity to produce fluidization:

$$G = \frac{0.00125\, D_p^2\, (\rho_p - \rho_f)^{0.9} \rho_f^{1.1}\, g}{\mu} \tag{6}$$

Agreement of (6) with experimental data is excellent.

Although flow patterns in fluidized beds are important in the chemical industry as well as in this coating process, definitive quantitative information is still incomplete. Recently, several investigators (1, 2, 8) have studied this problem using a variety of techniques. To date, no conclusive data which characterizes three dimensional flow patterns as a function of fluidization parameters is available in the literature. The effect of different kinds of distributor plates on degree and uniformity of fluidization has been studied by Grohse (8). He reported that fluidization was much improved when a porous disc was used rather than a sieve or a solid plate with holes in it.

In utilizing an open fluidized system, the amount of material which will be lost in the course of fluidization and the rate of loss are of concern. Unfortunately this problem has received little study. There is virtually no selective elutriation when narrowly sized particles are fluidized. Leva (12) found that for two differently sized particles elutriation proceeds according to the equation:

$$C = C_o\, e^{-0.908\, k\theta} \tag{7}$$

C and C_o are the concentration of fines in the bed at time θ and zero. k is a rate constant which is proportional to the fourth power of the gas velocity and depends on the particle size of the elutriated material.

Fluidizability of plastic powders and the effective densities of fluidized media are two more properties worthy of consideration. Whether or not a given powder will fluidize well appears to depend on particle size, moisture content, gas humidity, and electrostatic charge. A very simple and empirical test of fluidizability entails the use of a clean plate on which is placed a small mound of powder. One end of the plate is raised slowly. If the powder begins to flow down the inclined plane when the angle with horizontal is 45° or less the powder will fluidize. A variety of techniques have been proposed as fluidization aids. They fall into two general categories—agitators and contaminants. Agitation tends to break up agglomerates. Blade mixers, shakers, vibrators, sonic sources and ultrasonic generators have all been used with varying measures of success. The proper kind of particles added to a powder which is difficult to fluidize can produce remarkable effects in very small concentrations. In fact, reported data (11) indicates that too high a concentration of contaminant can have deleterious effects. The reported desirable properties of these contaminants are small particle size compared with the powder to be fluidized, nonhygroscopic, sizable electrostatic charge, and strong adherence to the larger particles. Such materials as pumice, corundum, silica and glass are effective. The repulsive forces due to electrostatic charges of same sign together with the strong adhesive forces between particle and additive tend to separate the particles to be fluidized from each other. The net result is improvement in ease and uniformity of fluidization.

Assuming uniform fluidization, the density of a fluidized bed can be expressed as:

$$\rho_B = \rho_p (1 - \epsilon) \tag{8}$$

$(1 - \epsilon)$ is in essence solids concentration. Extending the analogy between liquids and fluidized systems, $(1 - \epsilon)$ in fluidized systems is analogous to percent solids in liquid systems. On this basis, coating thickness should be proportional, to bed density via some mathematical function. The horizontal line B-C in *Figure 2*, which represents ideal fluidization, need not be altered in order for such a condition to prevail. In equation (1), L and $(1 - \epsilon)$ vary inversely and thus maintain constant Δp.

Although such problems as erosion and particle disintegration are important in many chemical and catalytic processes, they are not pertinent to coating processes using polymers.

Coating

Although coating in fluidized systems can be accomplished utilizing three general techniques–preheated part, charged particles, or a thin tacky undercoating, the use of preheated parts has received most attention to date. Independent of which technique is adopted, the resin particles must melt, flow together and cover the surface of the substrate. With the understanding that wetting and flow of polymers on solid surfaces is a complicated and extensive subject, some elementary concepts are outlined and reviewed below.

The ability of liquids to wet solids has been characterized by a spreading coefficient:

$$S = \alpha_\Delta (\cos \theta_\Delta - 1) \tag{9}$$

α_Δ = surface tension of the liquid (ergs/cm^2), $\cos \theta_\Delta$ = advancing contact angle, when θ_Δ equals zero, $S = O$ and spreading is a maximum. S is negative at all other values of θ_Δ. Unfortunately, data on surface tension and contact angles of molten polymers is virtually non-existent. Therefore, the somewhat empirical rule which states that the tendency for a liquid to wet a solid is a function of the difference in surface tension between the solid and the liquid is useful. The surface tension of a solid below its melting point is, for practical purposes, insensitive to relatively small temperature changes. The surface tension of liquids however decreases linearly with temperature:

$$\Delta\gamma \alpha (T_1 - T_2) \qquad T_2 > T_1 \tag{10}$$

Therefore at higher temperatures the tendency for liquids to wet solids is higher. Mullins (15) has derived theoretical expressions for the rate at which particles on a surface will flow to form a smooth surface at constant temperature. Although the derivation does not apply specifically to the cases at hand, it is apparent from his treatment that:

$$\text{Spreading rate } \alpha \frac{\gamma}{2\eta} \tag{11}$$

Therefore as the melt viscosity, η, decreases one can expect higher spreading rates.

Philipoff and Gaskins (18), and others have shown that at very low shear stresses, polymeric melts are Newtonian fluids. Since the entire coating process takes place at atmospheric conditions, one can expect Newtonian behavior. Of greater interest, however, is the temperature coefficient of viscosity. In general, the equation

$$\ln \eta = -\frac{A}{T} + B \tag{12}$$

holds for polymeric melts. The relation degrades in the vicinity of the melting point. The rate of viscosity decrease with increasing temperature is far greater than that for surface tension. Therefore as the temperature increases the spreading rate increases, equation (11).

It is important to note that the foregoing discussion applies only to one component single phase systems which behave almost ideally. For more complicated systems these relations should be used only as qualitative guides.

A. Pre-Heated Part

The use of this method for coating has been well described in technical literature (3, 7, 5, 16, 20). Time-temperature-coating thickness relations have been determined and pre-heating methods as well as techniques for heating in situ have been cited. Of interest may be the heat transfer phenomena. One of the advantages of fluidized beds is their high rate of heat transfer. Therefore hot parts might be cooled before they could be coated properly. However as soon as the heated part is immersed in the system, the particles which strike the surface fuse and adhere. An insulating layer is formed and the heat transfer rate is then limited by thermal conduction through the polymeric layer which is growing in thickness continuously. Simultaneously heat is being transferred from the surface of the polymer to the fluidized bed. One might conclude then that the higher the immersion temperature and the longer the exposure time the thicker the coating. The obvious limitation is that the temperature on the surface of the coating must remain higher than the melting range of the polymer. Theoretically, the rate at which the coating deposits should decay rather rapidly with immersion time initially and then proceed at a more or less constant rate.

B. Coating by Electrostatics

The use of charged particles and electrical fields to coat objects is not new. The Ransburg process in which droplets are charged, sprayed and attracted to grounded substrates is a well known successful industrial example. The migration of charged particles through a liquid under the influence of an electrical field to a substrate is another well known example. The use of electrostatic fields to remove charged particles from gas streams is still another example. Therefore, the feasibility of coating by electrostatic techniques in a fluidized system has really been demonstrated. A detailed treatment of the mechanism by which this technique becomes operative is beyond the scope of a survey article such as this. However, let us examine mechanisms in a general way.

A variety of investigators have reported that fluidized dielectric particles acquire electrical charges. In fact, sparks several feet in length have been observed from an ungrounded column, in which a powder was fluidized, to a grounded object. Standard practice now requires that all equipment associated with fluidized systems be well grounded–using a single ground. The precise mechanism by which the particles acquire these charges is not altogether clear. The quantity of charge appears to be directly proportional to surface area, air rate, time, and degree of expansion. Humidity decreases charging somewhat, ionized air reduces the charge to zero. It can be shown that fluidized dielectric particles acquire charge even in a grounded column. Charges as high as several billion electrons per square centimeter per particle have been observed in a fluidized bed. The

equation for charge acquired by particles exposed to high potentials has been formulated as:

$$n = \left(\frac{3 E_o a^2}{e}\right)\left(\frac{t}{t + \frac{1}{\pi N_o e_u}}\right) \qquad (13)$$

n, the particle charge in electrons is proportional to E_o, the electric field, a^2, the square of the particle diameter, and t, time the particle is exposed to the field. $\frac{1}{\pi N_o e_u}$ is essentially the particle charging time constant. The saturation charge approached at large values of t is $n = \frac{3E_o a^2}{e}$.

To reasonable approximation the force which opposes electrostatic deposition is given by Stoke's law:

$$F_r = 6\pi nav \qquad (14)$$

Assuming that the piece to be coated is a grounded conductor the force attracting the charged particle to the conductor is:

$$F_a = -\frac{q_p^2}{4r^2} \qquad (15)$$

For dense beds, the surrounding particles may be assumed to act like planes of charge. Then the attractive force becomes:

$$F_{aa} = \frac{2\pi Q_A^2}{c_b} \qquad (16)$$

If charged conductors or non-conductors are used as substrates, other forces come into play and must be accounted for. Combining equations (14) and (15), the velocity component in the direction of the immersed part is:

$$v = \frac{q_p^2}{24\pi\eta a\, r^2} \qquad (17)$$

Once the particles are attracted to the grounded conducting surface, they are held by electrostatic forces. For simplicity, it is expedient to assume that only the outermost layer of powder behaves as a charged plane. Then equation (16) applies. The charge is that on the outermost layer, Q_A. For the actual case, particle to particle charge interaction throughout the volume of particles must be considered as well as the interaction of those particles which are adjacent to the grounded conducting surface. The simplifying assumption does not introduce as large an error as might be presumed at first sight. It can be shown that highly charged particles behave somewhat like conductors. In contact, they will tend to assume an equilibrium energy which is a minimum. This corresponds to charges which reside on the surface alone. During deposition, additional particles are attracted to the layer of powder which has already been deposited by image charges in the substrate due to the charged particles in the bed and by image charges induced in the particles by the charge on the outer layer of powder. This latter attractive force, dielectrophoresis, can be represented mathematically as (19):

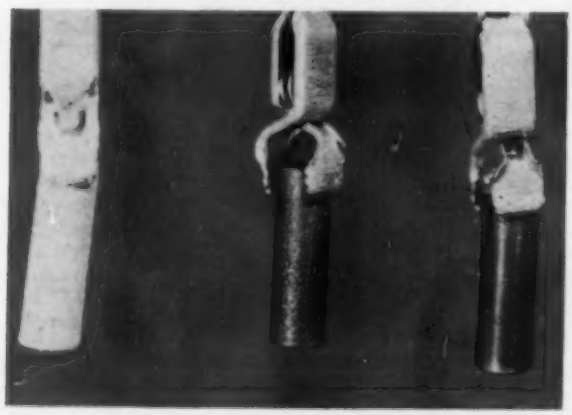
$$F_D = c\left(\frac{c_s - c}{c_s + 2c}\right)\left(\frac{D_p^3}{8}\right) E\left(\frac{\partial E}{\partial r}\right) \qquad (18)$$

where $\frac{\partial E}{\partial r}$ = field gradient at the particle position.

When the part containing the powdered coating is removed from the fluidized system, the force holding the powder on the substrate is given primarily by equation (16). A specific example will illustrate the relative magnitude of the forces involved and thus the possible utility of this technique. Assume charge per particle per cm^3 = one esu, dielectric constant = 3.14, powder polymer coating bulk specific gravity = 0.5, and surface area of part to be coated = one $ft.^2$. Then the theoretical thickness of the layer of powder which could be held by electrostatic forces = 40 mils. The coating when fused might be 20 mils thick.

It appears then that this technique deserves further exploration. The severity of such problems as masking and corner coverage are materially reduced. Further, it is possible to fuse the coating only, without heating the entire part. The chief drawbacks to the use of this method appear to be the rigid control of process conditions which may be required to permit reproducibility as well as a natural reticence encountered whenever highly charged particles are considered for use in a process. *Figure 3* is a photograph of an aluminum cylinder coated by this technique.

Figure 3. Aluminum cylinders, showing three phases of operation, coated in a fluidized bed by electrostatic technique.



Thin Adhesive Undercoating

Perhaps the best evidence to substantiate the utility of this method of coating is to point out a specific example. *Figure 4* is a photograph of a small transformer coated with polymethylmethacrylate utilizing a thin tacky coating as a base for the powder. Once again this technique can be of distinct advantage where masking is difficult or if the part to be coated is very large or bulky. A great deal of waste heat can be avoided by fusing the coating only. Paint, spray and dip techniques are all useful in applying the tacky undercoat. The adhesive can have the same chemical com-

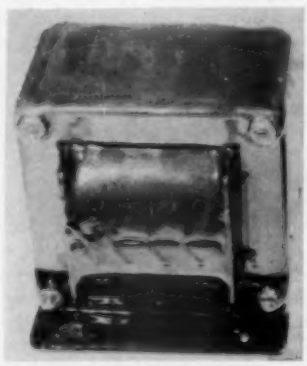


Figure 4. Small transformer coated in a fluidized bed using a tacky undercoating.

position as the coating material or it can be a platsicizer for the coating or it can even react with the coating material. Further variations are left to the imagination of the reader.

Safety

Hartmann (9) has recently published data and information relating to safety in the use of powders. If the approximate assumption that a stoichiometric balance between oxygen and a flammable solid is required before an explosion or a fire can occur is correct, then neither explosion nor fire can occur in a fluidized system using plastic particles. Based on methyl methacrylate, the molar ratio of plastic to oxygen required for ignition is 0.17, the molar ratio present in the usual fluidized bed is 810. One might conclude erroneously that there are no hazards. Certainly, short time sparks or hot spots would not ignite a fluidized bed, first because there is insufficient oxygen present and second because cooling is so rapid. However, if the bed were operated at some elevated temperature, perhaps close to the melting point of the polymer, and a source of sustained high temperature were inserted this could result in local ignition. Such a small explosion could throw dust into the air resulting in further ignition and so on until the entire mass were consumed. Therefore operation at elevated temperatures and inserting sources of heat at temperatures above ignition temperature with considerable capacity for heat retention is hazardous. The surface area of the heat source is also important, since rate of heat transfer is proportional to contact area.

The most important aspect of safety is good housekeeping. The greatest hazard is due to a secondary explosion caused by dust which has been blown into the atmosphere and been permitted to partially settle out at various sites. At some point in the dilution of the cloud, the proper stoichiometric ratio for ignition exists. At this point, an electric spark, a lit match or cigarette, or any other source of energy such as a hot motor will provide the minimum energy necessary for a secondary explosion. This first and probably mild detonation can cause other and more serious explosions. If nothing else, it can blow more powder out of the bed and provide material for successive detonations, each successive one stronger than the one before it. Therefore, in addition to good housekeeping, all equipment should be grounded, all electrical apparatus should be dustproof and the entire area should be kept well ventilated and clean. Open flames although not a direct hazard, should nevertheless be avoided.

Glossary

a	=	particle radius (cm)
A,B,	=	empirical constants
c	=	dielectric constant of gas (dimensionless)
d_p	=	diameter of particle (ft)
ϵ	=	fraction voids (dimensionless)
E	=	field strength between particle and substrate (volts/cm)
e	=	electronic charge (4.8×10^{-10} e s u)
E_o	=	electric field to which particle is exposed (volts/cm)
c_2	=	dielectric constant of particle (dimensionless)
F_a	=	attractive force (dynes)
F_{a_1}	=	attractive force (dynes/cm²)
F_r	=	retarding force (dynes)
G	=	mass velocity (#/hr-ft²)
g	=	acceleration of gravity (ft/hrs²)
g_c	=	Newton's law conversion factor $\frac{\#\text{mass}}{\#\text{force}}$ ft/sec.² = g (numerically)
k	=	rate constant
M	=	ion mobility
N_o	=	ion density in charging zone
n	=	particle charge (electrons)
Q_A	=	charge of plane on substrate (esu/cm²)
q_p	=	charge on particle (esu)
S	=	spreading coefficient (erg/cm²)
T	=	temperature °K
t	=	time particle exposed to field (sec)
u	=	superficial velocity (ft/sec)
r	=	distance of particle from surface (cm)
Δp	=	pressure drop (#/ft²)
$(1-\epsilon)$	=	fraction solids (dimensionless)
ρ_p	=	density of solid particles (#/ft³)
ρ_f	=	density of gas (#/ft³)
ρ_B	=	bulk density (#/ft³)
μ	=	viscosity (#/ft-hr)
C	=	concentration of fines at time = θ
C_o	=	concentration of fines at time =O
θ	=	time constant (seconds)
σ_A	=	surface tension of liquid (ergs/cm²)
θ_A	=	advancing contact angle (degrees)
η	=	viscosity (gm/cm-sec)–
v	=	velocity of particles (cm/sec)

Literature References

1. Bartholemew, Casagrande, *Ind. Eng. Chem. 49* 428 (1957)
2. Baumgarten, P. K., Ph.D. Thesis, Univ. Del (1956)
3. Checkel, R. L., Mod. Plastics, Aug. 1957
4. Ergun, S., Orning, A.A., *Ind. Eng. Chem. 41* 1179 (1949)
5. Flourney, R. W. Corrosion *11* 289T (1955)
6. Furakawa, J., Ohmae, T., *Ind. and Eng. Chem. 50* 821 (1958)
7. Gemmer, E., *Kunststoffe*, Aug. 1957
8. Grohse, E. W., *A. I. Ch. E., Journal 1*, 358 (1955)
9. Hartmann, F., *Chem. Eng. Prog.* 53 107M (1957)
10. Industrie-Anzeizer, 75 Iahrgang No. 12, Feb. 10, 1953, pp 141-143
11. Irani, R. R., Callis, R. F., Lie, T., ACS meeting, April 1959 "Effect of Solid Additives on Flow and Caking etc."
12. Leva, M., *Chem. Eng. Prog. 47* 39 (1951)
13. Leva, M., Grummer, M., Weintraub, M., and Pollchick, M., *Chem. Eng. Prog. 44* 1220 (1948)
14. Miller, C. O., and Logwinuk, A. K., *Ind. Eng. Chem. 43* 1220 (1951)
15. Mullins, W. W., *J. Appl. Phys. 30* 77 (1959)
16. Newman, I. A., Bockhoff, E. J., *Prod. Eng. 28* 140 (1957)
17. Parent, J. D., Yagol, N., and Steiner, G. S., *Chem. Eng. Prog. 43* 429 (1947)
18. Philipoff, W., Gaskins, H., *J. Poly. Sci. 21* 205 (1956)
19. Silverman, L., Conner, E. W. Jr., Anderson, D. M., *Ind. Eng. Chem. 47* 952 (1955)
20. Stott, L. F., *Materials and Methods 41* 92 (1955); Orgn, Fin *54* 90 (1956)

The Thermal Incline as an Evaluation Tool in Fluidized Bed Coating

C. J. Metz
Union Carbide Plastics Co.

The preceding article outlined various techniques for coating objects using the fluidized bed process. This article goes one step further and gives a method for measuring the flow of coating powders at different temperatures

The thermal incline is an apparatus for measuring the flow of coating powders at different temperatures. It consists of a heavy aluminum plate, with a controlled heater at one end. Thermocouples are located at various points along the plate, and are attached to a recording potentiometer. A layer of silicone stopcock grease is spread on the plate, and then a piece of aluminum foil is placed over it. Pellets of uniform weight, made from the coating powder to be evaluated, are placed along the top edge of the plate. After a specified level period, which may vary from one resin to another, the plate is tilted to an angle of 60° below the horizontal. The length of flow of each pellet is measured, and then a graph of flow vs. temperature is plotted.

Application of Thermal Incline to Fluidized Bed Coating

This test is especially adaptable to fluidized bed coating for relating the flow of the coating material to the substrate temperatures. There are three areas where the thermal incline test has been found useful.

The first, and most obvious is the determination of the temperature where optimum flow occurs. This is generally the point of maximum flow. A very important piece of information is the lowest temperature at which a substrate can be coated. These two points are illustrated with the help of *Figure 1*, where the thermal incline characteristics of epoxy compound A* are shown. It was found that the minimum substrate temperature at which resin A could be successfully coated was 140°C, and that the smoothest coating was obtained at 170°C. These experimental results agreed closely with what would have been predicted from the thermal incline curve.

A second type of curve is illustrated on *Figure 2*, for epoxy compound B* With this material, the decrease in

* Epoxy compound A, an experimental material, was found unsuitable for fluidized bed coating. It is included here merely to illustrate the evaluation procedure.

* Experimental epoxy compound based on Bakelite Brand EKRB-2014.

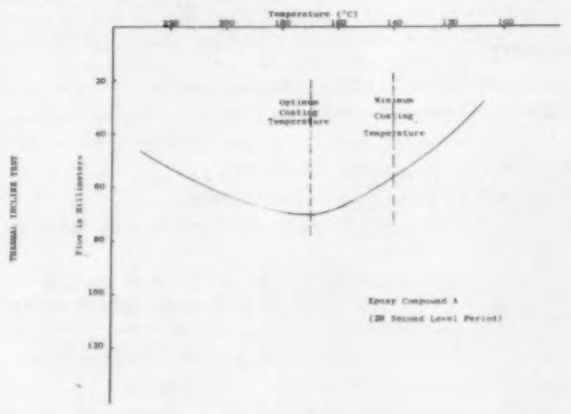


Figure 1. Optimum coating temperature is about 170°C.

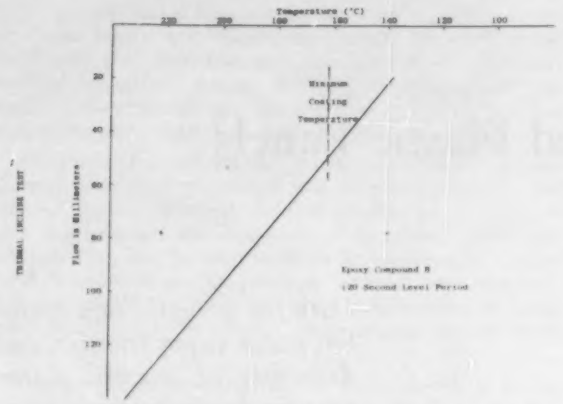


Figure 2. Flow continues to get longer as temperature goes up.

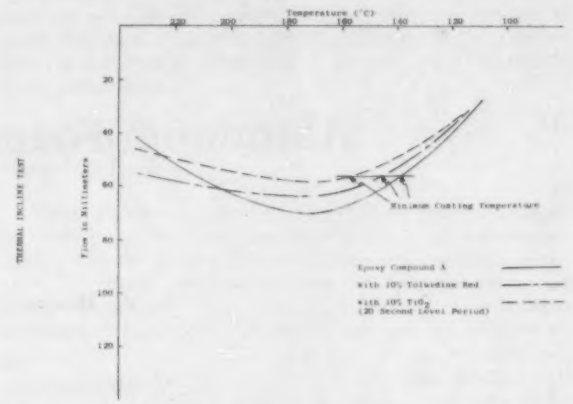


Figure 3. Effect of fillers and pigments on flow.

viscosity found with rising temperature has more influence on the flow than the decrease in gel time, and consequently flow continues to get longer as the temperature rises. It has been found experimentally that substrate temperatures below 160°C do not yield smooth coatings. The flow of about 50 mm at 160°C for compound B, is quite close to the flow shown by compound A at 140°C, with a level period of 20 seconds.

The second area is the effect of fillers and pigments on the flow. *Figure 3* shows the predictable shortening of flow when A is compounded with toluidine red and with titanium dioxide.

However, an interesting effect is found with compound B, where the addition of toluidine red actually lengthens the flow. This is shown on *Figure 4*. The more expected shortening of flow is found with titanium dioxide.

It is useful to determine how much the minimum coating temperature is raised by the addition of pigments. With compound A, the minimum coating temperature is raised about 20°C to 160°C, by addition of 10% titanium dioxide. This would have been predicted from the thermal incline patterns, as shown on *Figure 3*.

The third area is checking on storage stability.

Compound A is a physical blend of epoxy and hardener, and therefore has a long storage life, at least one year. It shows no change in thermal incline pattern upon storage.

Compound B, however, is a "B-staged" mixture of epoxy and hardener, and does have a limited storage life. *Figure 5* compares the thermal incline patterns of compound B immediately after production, with the pattern after one month of storage. It is seen that the flow is shortened, and the minimum coating temperature has been raised from 160°C to about 170°C.

Although the flow is shortened, the powder is still useable, and continues to be so for about two more months. *Figure 5* also illustrates the difference in thermal incline pattern obtained by using different lengths of time for the level period. This points out the necessity for using the same level period when running comparisons between different materials.

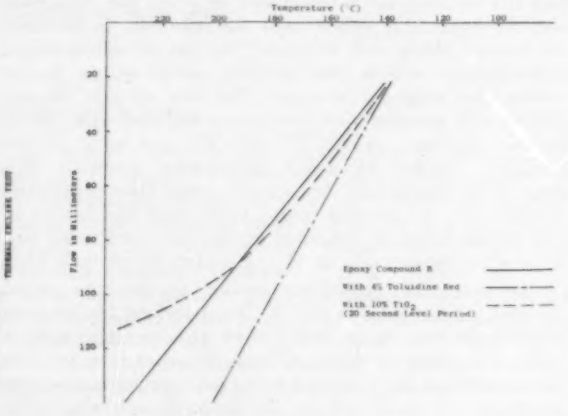


Figure 4. The addition of toluidine red actually lengthens flow.

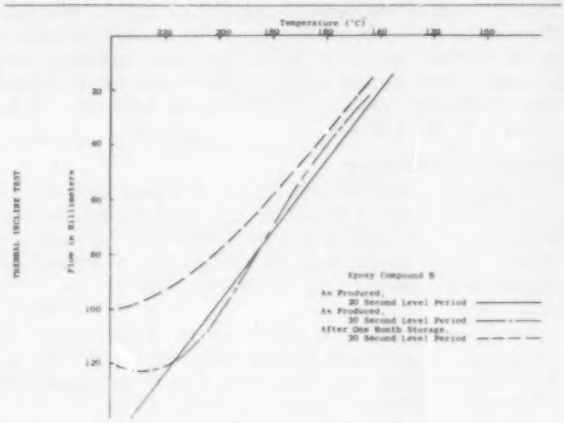


Figure 5. After one month of storage, flow is shortened, and the minimum coating temperature has been raised from 160°C. to 170°C.

Aluminum-Foamed Plastic Panels

L. W. Hovland,
Aluminum Company of America
and
E. R. McLaughlin,
The Pennsylvania State University

Data for strength, heat transfer, water vapor transfer, and deflection of foamed plastic core sandwich materials.

Combinations of materials can often be used to form a product that performs its function better than if it were made exclusively of one material. Nowhere is this principle better illustrated than in sandwich panels. By using a lightweight core material having good thermal insulating properties, to which are bonded exterior facing sheets of more dense, higher strength material, one arrives at a lightweight composite insulating panel having enormous strength and stiffness. By placing the relatively high strength material on the extreme surfaces and using the lighter core material simply as a shear resistant filler or spacer well bonded to the facing sheets, maximum advantage is taken of the properties of each material so as to attain specific advantages for the whole assembly. Such as assembly is commonly called a sandwich panel.

The particular sandwich panels discussed herein, have aluminum facings or aluminum exterior facings in combination with other decorative or paintable interior facings such as plywood. The aluminum facings may be bonded directly to the core or they may be bonded to hardboard or other backup materials which in turn are bonded to the core. The core material referred to as foamed plastic is lightweight expanded polystyrene of 1 to 2 pounds per cubic foot density. Various combinations of panels can be classified under three types, depending upon the primary or exterior facing. Various interior or secondary facing materials, may be used. Some special panels include rails for additional shear resistance, for the attachment of hardware, or for joining one panel to another.

Structural Advantages

Among the foremost advantages of aluminum-faced expanded plastic cored panels is high strength-weight ratio. A typical 3-inch panel 4 feet by 8 feet with .025-inch aluminum facings weighs only 39 pounds. Yet, this panel can support a distributed load of 1500 pounds over an 8-foot clear span.

Panels are available in widths up to 48 inches and the panels can be produced to any practical length required. The core thickness may vary from 1 to 6 inches. In constructing a prototype house 4-inch by 4-foot by 28-foot panels were used for the roof. Walls utilized 3-inch by 4-foot by 8-foot panels. The length may be governed by distortion, where a temperature difference exists across the panel.

Aluminum facing sheets are ideal for structural sandwich panel construction. They offer good structural strength and stiffness, excellent resistance to weathering and corrosion, perfect vapor barrier characteristics, a wide variety of patterns, forms, colors and textures, and good wear and dent resistance qualities. Where maximum dent resistance is an important factor, it may be desirable to incorporate some form of backup board behind the aluminum facing sheets, thus permitting thinner aluminum facing sheets to be used.

The exceptional insulating property of the foamed plastic core provides excellent thermal characteristics for the panels, superior to many older types of construction. "U" values of typical sandwich panel constructions with nonreflective surfaces are shown in the tables following text. The "U" values in this figure are calculated on the basis of a conductivity k for the plastic foam core of 0.25. The foamed plastic core of the panel has a low permeance (1-2 perm inches) which helps maintain its usual good thermal insulating properties. Where a vapor pressure differential is likely to exist in service, the low permeance of the core should be supplemented by the use of a vapor barrier on the interior facing or warm side. Aluminum facings or foil bonded to permeable facings on the warm side of the panels will serve as positive vapor barriers.

The foamed plastic core made from expandable polystyrene beads is a foam which is a white opaque material that has no food value for animal or plant life. The foam and the expanding agents used are nontoxic. In addition, the foamed plastic core is non-friable, has self-extinguishing characteristics and is dimensionally stable within the recommended temperature range. The core material is compatible with aluminum under extreme exposures such as six months exposure at 125°F and 100 per cent relative humidity. Similar expanded polystyrene materials have been used successfully for various applications, primarily as insulation, for the past twelve years. This fact lends support to the favorable results of accelerated weathering tests which have been made on the expanded polystyrene foam.

The maximum continuous service temperature recommended for the foam is 175°F. Panel surface temperatures of short duration up to 200°F have been recorded with no noticeable effect on the foam core. Panel surface temperatures exceeding the maximum continuous service temperature would cause loss of strength and eventual collapsing of the foam core itself at the interface of the facing sheet. This could cause a panel failure and possible failure of a structure if the panels were used as primary load-carrying members. Such structural failures can be minimized by the use

of shear webs or rails within the panel which make the panel a combination stressed skin and sandwich panel construction. Panels with aluminum facings, however, would contribute very little fuel to a fire because of the incombustible facings and the low density core, together with the core's self-extinguishing characteristics. Aluminum-faced panels are also resistant to flame spread.

Aluminum foamed plastic panels with their inherent thermal insulation properties and excellent strength and stiffness in any direction, lend themselves to all types of uses where solid, flat structural or decorative panels are needed. They can be used to fill in the openings in a structural framework or as primary load-carrying members. Being available in a wide variety of combinations of facing materials, they can be adapted to almost any type of application.

One of the outstanding uses of these panels is in the construction of simple, box-like thermally insulated enclosures such as refrigerators. A long panel of suitable width can be notched and folded so that only one joint, rather than the usual four, is required to close in the four sides as shown below. A suitable back panel and door, attached separately, complete the box.

Sandwich panels are ideal for walls and roofs of residential and other construction. They combine in a single unit, strength, corrosion resistance, color pattern, insulation and desired interior facing and finish. Panels provide for a fast, low-cost system of construction that eliminates conventional framing, sheathing, siding, plastering, painting and decorating. Foamed plastic panels can be applied economically to many other uses such as controlled temperature rooms, curtain walls, portable buildings, mobile homes, doors, movable partitions, folding partitions and doors, ceilings, refrigerated truck and trailer bodies. containerization units, portable coolers, refrigerated dispensing machines, and many other applications.

Panels can be joined in various ways, depending on how the panels are used. For instance, the panel may be used essentially as a piece of glass and gasketed or sealed in a corresponding manner. Joints of this type simplify panel construction since generally no special edge conditions are required and panels can be trimmed in the field if necessary.

Some other types of joints employing splines, battens and other features will be illustrated in the tables following. Joints similar to those shown were included in a test unit built at The Pennsylvania State University's Engineering Research Thermal Laboratories. The following general observations were made:

Weather Tightness

Joints that are required to resist leakage of air and moisture can be sealed by means of gaskets, tapes, sealers, or combinations of sealing materials. It is quite often desirable to use wet sealers in combination with gaskets or tapes especially at the corners where vertical members join with horizontal members. To obtain a good weather seal with gaskets, positive pressure must be applied to the panel and the gasket material must be flexible enough to maintain this pressure even though thermal stresses may cause panel movement and dimensional changes in the frame itself. Tapes must also be strong and flexible and capable of adhering to the panel faces. At random intervals throughout a cyclic test program which will be described in detail, a static pressure differential of up to 1.7 inches of water, or the equivalent of a 60 m.p.h. wind, was brought to bear on the tets unit. The interior was held at negative pressure. Pressure, applied in conjunction with the water spray to simulate wind-driven rain, provided an effective measure of joint efficiency. The return edge and plug, batten, spline, and several taped joints tested showed good all-around joint performance.

Heat Conduction

Where panels are used for insulating purposes, care must be taken to prevent heat loss through the joints, which may result in frost, condensation, or dirt accumulation at the joint. "Through" metal connections between the inside and outside faces must be avoided or minimized. This is especially true where high relative humidities and high temperature differences across the panels are encountered. This can be accomplished in the batten type joints by reducing the through conductance to the fasteners only. Through conductance can be further reduced by joining the fasteners with plastic sleeves. During a steady state test in which outside air temperature was lowered to −20°F and held constant for five hours, the insulating qualities of aluminum batten joints with two metal fasteners 9 inches on center were checked. The minimum air space between the inside and outside batten was ¼-inch. The interior air temperature was held at 75°F and the surface temperature of the inside battens averaged about 47°F. The surface temperature of the joint where plastic sleeves were used and the minimum air space was 3 inches measured 67°F. The relative humidity was maintained at 31 per cent which was the R.H. at which condensation formed on the insulated glass The dew point was 42°F which is below that of the two joints described above. Frost formed at the sill where through conductance did exist and the temperature recorded was 23°F. If hygroscopic materials are used as thermal breaks in joint design, they must be protected adequately to prevent changes in moisture content with the resulting dimensional changes.

Expansion and Contraction

If the aluminum faces of the panels are subjected to appreciable temperature changes, the joints between panels should provide for the resulting panel movement either by slipping between the mating parts or by flexing of suitably designed elements of the joint. Panel movement or distortion is covered in detail under the laboratory evaluation of the panels.

Protection of Edges

The exposed adhesive line on the edge of any panel facing which is exposed to the weather should be protected. All the joining methods shown provide for the protection of the panel edge. Aluminum channels or other extruded shapes may be used to enclose panel edges in certain applications.

Ease of Erection

Erection problems must be kept in mind when designing joints. Some types of joints require that a special erection sequence be followed. Other types do not require a special erection sequence and have the further advantage that single panels can be removed without requiring the removal of the entire assembly.

Strength Properties of Aluminum-Faced Foamed Plastic Panels

Sandwich panels are considered as I beams in determining strength properties. Transverse bending is resisted by the faces or "flanges," and transverse shear is assumed to be resisted entirely by the core or "web." Tension, compression, or shear loads in the plane of the panel are considered to be carried entirely by the faces.

The strength of aluminum-faced panels is generally limited by either the shear strength of the core or the local buckling strength of the compression face. Except for long columns, whose strength is limited by column buckling, local buckling also governs strength of panels loaded in edge compression. The safe load tables shown here are based on the following values:

Working Stresses For Applications Not Involving Elevated Temperatures (For Effect of Elevated Temperatures, see Tables).

Compression in Aluminum Face	2000 psi
Shear in Core	2.5 psi
Shear in Wood Shear Web	60.0 psi
Moduli of Elasticity	
Modulus of Aluminum	10,000,000 psi
Modulus of Treated Hardboard	800,000 psi
Modulus of Cement Asbestos Board	2,000,000 psi
Shear Modulus of Core	400 psi
Shear Modulus of Wood Shear Webs	50,000 psi

Safe uniform loads for panels up to 6 inches thick with 0.032-inch aluminum compression face sheet are shown in the tables. Safe shear loads are shown also as well as safe bending moments.

The effect of temperatures on the safe load values is shown. Up to 110°F the temperature has no effect on the safe load value. As the temperature of the compression face goes above 110°F the safe load is reduced until, at about 175°F, the load the panel can carry is limited essentially to 20% of original or that which can be carried by stressed-skin action.

The deflection of foamed plastic core panels can be calculated by use of the equation and the coefficients given in the first diagram of the tables.

Thermal Insulating Value

Coefficients of heat transmission are plotted against panel thickness. The lower curve shows the U values for plain panels without edge framing. The upper curve shows the U value for panels with wood framing at all four edges.

The thermal conductivity of the core material is approximately 0.25 Btu per sq. ft., hr., degrees F/in.

Cost

The cost of foamed plastic panels is dependent upon the panel construction, finish, size, and quantity of any one size required. The wide selection of facing materials together with patterns, textures, finishes, etc., make it difficult to establish a price list for panels in general. However, panel constructions could be standardized for many applications. For example, panel inserts for a grid type curtain wall construction could be made of a standard width with only slight variations in thickness and facings used. Variations in length would not affect the cost appreciably since the panels could be made in long lengths and cut to specified length. A panel could be constructed as follows:

1. Exterior Facing—.032-inch aluminum.
2. Exterior Backup—¼-inch tempered hardboard
4. Interior Facing—¼-inch cement asbestos board

The above panel was quoted for a specific job in which all the panels were 2-inch by 4-foot by 4-foot at $1.37/square foot. The addition of a foil vapor barrier to this panel at the present time would have added about 10 cents per square foot to this panel. If a panel were standardized for this particular application, it is quite likely that the cost of this panel would be reduced.

Laboratory Evaluation

New materials and new combinations of materials appear frequently on the scene without benefit of adequate use experience to define their expected useful life and suitability for the purpose proposed. To obtain a quick evaluation of the behavior of new materials in critical exposures, certain test procedures have been devised to demonstrate specific properties. Comparisons with known data provide some basis for evaluation. Certain features of the test may be emphasized to provide an accelerated exposure that will yield a result in a shorter time. Because of lack of time, a laboratory test is usually accelerated, of short duration and carried out under controlled conditions so that the test can be repeated on other samples.

To study the behavior of full scale sandwich panels and their frames, a full scale wall enclosure was erected in the Climatometer at The Pennsylvania State University. Full-size wall panels, frames, windows, and roof panels were exposed to several climatic conditions. A series of temperature cycles interspersed with water spray was designed to make the panels work and stress gaskets and sealants, and to stress the bond between face materials and core. Radiant lamps heated the exterior surfaces to 180°F, a temperature that is possible for a dark colored surface under solar radiation. The surface was quenched with a water spray to reduce its temperature quickly and accelerate the movement between panel and frame. Each cycle consisted of three such phases before the air temperature was lowered to produce a surface temperature of 0°F. All four phases of a temperature cycle were completed in eight hours. This permitted running through twenty cycles in a reasonably short time. During the cycling, observations were made of the deflection of the panels and observers were alert for water leakage during the spray periods. A typical deflection record during a complete cycle appears in tabular pages. As the outside air temperature drops, the wall panel deflects inward more along a vertical centerline than along the horizontal centerline. As the exterior heats, the deflection is outward and the panel cups in the other direction. Deflections of a 3-inch by 4-foot by 8-foot wall panel as a function of the temperature difference between the two faces is shown in which "vertical" refers to the vertical gauge length and "horizontal" to the horizontal gauge length.

The vertical gauge length was 91.5 inches. With 100 degrees temperature difference, the deflection of 0.32 inches gives a span to deflection ratio of 286. This deflection is less than a deflection obtained by dividing the span by 240 as permitted for metal roof decking under build-up roofs. A deflection obtained by dividing by 175 is permitted for metal window frames.

This panel was faced on the exterior with 0.032-inch aluminum sheet backed with ¼-inch cement asbestos board. Core was 2 5/16-inch foamed plastic insulation. Interior finish was ¼-inch decorative plywood. The maintenance of a nearly constant indoor air temperature permits a very small fluctuation in the interior surface temperature. On the other side, the wide variation in exterior air temperatures produce big variations in exterior surface temperatures. For these reasons, it is not possible to laminate a sandwich panel which will be free of any distortion. Deflection due to temperature differential is primarily a function of the thermal expansion coefficient of the exterior face material.

For aluminum-faced panels, the measured panel deflection can be expressed by the empirical formula $\frac{0.00019\ L^2\ \Delta t}{T}$ where L is the gauge length in feet, approximately equal to panel length

T is the panel thickness in inches

Δt is the temperature difference, surface to surface, in degrees F.

Note that the deflection is a function of the gauge length squared divided by the thickness.

Wall panels are subject to pressures generated by wind. To simulate this condition of pressure differences, a fan was used to exhaust air from the srtucture at a rate which reduced the interior pressure as much as 1.7 inches below the exterior pressure. This is similar to the condition created by a wind of 60 mph impinging directly onto the wall. While this reduced pressure was maintained, water was sprayed onto the outside surface of the panel and frames. The interior surfaces of the walls were inspected for leakage at all joints, gaskets, and corners.

To prevent leakage under pressure conditions, gaskets and sealers must be continuous and must bear against the panel and frame. Where they fail to do this, leakage is almost certain to develop under wind-driven rain conditions. The thinness of the wall, which is a major asset for curtain walls, does not permit or provide space for a drain to carry away incidental leakage without its being visible to the observer in the building.

Where flashing is utilized, it must be continuous and deep enough to hold a water level at least equal to the maximum dynamic head of the greatest wind velocity anticipated. A wind of 60 mph will generate a pressure differential of 1.7 inches of water. A 100-mph wind will support 4.8 inches of water, the equivalent of 25 pounds per square foot.

Steady State Tests

During a cyclic exposure, the panel is continually seeking equilibrium with its surroundings and its temperatures and deflections are dynamic. Also, relatively little time is permitted for frost and condensation patterns to develop. To show the conditions that will prevail under steady state exposures, the panels were subjected to an air temperture of −20°F outside while the inside conditions were maintained at 75°F and 31 per cent relative humidity. At this condition, the dew point of the air was 42°F and condensation was expected on all surfaces below 42°F. In fact, the edge of the condensation pattern defined a line at or near 42°F.

Heavy condensation was observed as frost on the sill where the temperature was measured as 23°F. Vertical columns properly designed to break the through conductance of the metal showed no condensation except at their bases where they joined the cold sill. Metal fasteners extending through the panel showed frost on the interior. These conditions are nearly severe enough to cause condensation on the double plate glass. This provides a criterion for the performance of the panels, since any wall having windows will be protected to a great extent by the onset of condensation on the glass. Once the conditions become severe enough to cause condensation on the glass, the glass acts as a condenser of the excess humidity and the humidity can rise no higher unless there is a generous source of water vapor.

The foamed plastic core panels showed high interior surface temperatures only five to six degrees below the interior air temperature when the outside air temperature was −20°F or 95 degrees F below the room air. This is a favorable factor in evaluating the comfort of a space surrounded by these walls.

Wall panels are subjected to another differential which threatens their performance. The humidity on the inside creates a water vapor pressure higher than that existing outside, or in some instances higher than the vapor pressure within the wall. Typical values are 19 lb per sq. ft. inside and, at −20°F, slightly more than 1 lb per sq. ft. outside. The indoor pressure therefore keeps driving the vapor through any permeable facing material or through the foamed core material or through cracks or open joints in either material.

To evaluate the panels under this action, samples were exposed to temperatures of 80°F on the warm side and −20°F on the cold side. One half of the total number of samples was exposed to 40 per cent R.H. on the warm side while the other half was exposed to 75 per cent R.H. Weight observations before and after a six weeks exposure indicated the moisture pick up of the panels. Closer observation revealed, however, that the major portion of the moisture gain was in the face materials where the facing was a material other than metal. Panels with continuous metal interior facing materials gained no weight, but the hygroscopic materials, such as wood, etc., not only absorbed water but were subject to warping with some delamination.

A panel with perforated aluminum interior facing and subjected to the 75 per cent R.H. condition picked up only 0.42 lb of water during the six weeks period. The major portion of this water was observed to be between the edge sealing tape and the edge of the panel. When the edge tape was removed, the water evaporated quickly, indicating very little penetration into the core material.

Observations of panel surface temperatures indicated no serious impairment of the insulating value of the foamed plastic core. It is evident, however, that core materials having a high resistance to the flow of water vapor are an asset to the panel and provide more freedom in the choice of interior finishes.

Acknowledgment

The data included in this paper were developed from two primary sources. Heat transfer, water vapor transfer, and thermal deflection data were determined by research under the direction of E. R. McLaughlin at The Pennsylvania State University. General panel information and strength data were supplied by a panel research team of the Aluminum Company of America composed of Dr. John W. Clark, E. C. Hartmann, E. T. Englehart and L. W. Hovland. Permission to publish the data from these two sources is duly acknowledged.

Charles G. Kepple

Motorola Incorporated

A method for measuring the bond strength of copper applied to plastic hose material.

Continuous Peel Strength Measurement of Copper Clad Laminate

MEASUREMENT of the bond strength of copper applied to a non-conducting base material for prefabricated circuitry applications has been a problem since the development of these materials.

The earliest, and still predominating method for measuring this bond strength, is the peel test whereby a strip of copper is partially peeled away from the base material and mounted on a support with the copper on the downward side. A bucket is fastened to the partially peeled strip and weights gradually added to the bucket until a point of release is obtained. The weight of the loaded bucket and clamp assembly gives the bond strength for that particular width of strip at the specific line of contact. This will normally be a maximum value in that even though partial release is obtained the bucket is continually loaded until there is complete release. The method is not entirely satisfactory since minimum values cannot be obtained.

New Method

A method has been developed by which the bond strength can be read over a considerable area and the variations determined that existed throughout this area. The method uses a Dillon Universal Testing Machine, modified to take a standard cross head with a two-screw drive rather than the single-screw drive head original equipment. A test fixture with a ball bearing mounted carriage was constructed to mount on this cross head. It is so designed that the carriage will move transversely with respect to the movement of the cross head of the test machine. The carriage is attached to the frame of the machine by cables in such a manner that the movement in the transverse direction is at the same rate of speed as the vertical movement of the cross head. This transverse movement will maintain a 90° angle between the laminate and the force required to peel the copper. The carriage is also provided with a heating element and temperature control device so that tests can be conducted at elevated temperatures. A sample of the material to be measured is clamped in this carriage and enough of the copper is stripped from the surface to permit attachment to the loading device. The load is provided by means of a pendulum and pulley assembly. The pendulum is not restricted so that it is free to rise and fall creating the magnitude of the force necessary to peel the copper from the laminate. One test specimen was 1" wide by 6" long, with a 0.4" wide strip of copper in the center of the 1" dimension. In mounting the specimen in the fixture it was clamped along the 6" dimension ⅛" in from the edge along both edges. Although any width of copper can be measured, a standard 0.4" wide copper strip was used for our measurements, and by adapting a special pulley to the loading mechanism this test width is automatically corrected to pounds per inch width on our charts. Any other widths that are tested would require correction of the measured values.

The adaption of this larger pulley has increased the sensitivity of the machine to the degree that speed of testing does not have too strong a bearing on the end results. A series of the same material were run at different speeds (1/10, 1/2, 1, and 2 in./minute) with the resulting charts being well within the range of the normal testing variations of any individual speed of test. Consequently we have established 2 in./minute as the standard testing speed to reduce the amount of time necessary to conduct tests.

Tests on Glass Epoxy Boards

To demonstrate the application of this test a group of copper clad materials were run under the conditions described above. The first of this series was a group of glass epoxy boards which were tested at room temperature, obtaining measurable results from only one out of three materials available. The bond of the other two was stronger than the copper foil, causing the foil to tear and making it impossible to get an accurate reading. The one material that was measured showed a measurable peel bond strength of approximately 10 lbs./inch width. Two materials that could not be peeled at room temperature were rechecked at 65°C. Both were measurable at this temperature—one being very erratic varying from a low of 4 lbs./inch width to 9 lbs./inch width. Then standard copper clad from four suppliers was checked.

Laminator "A" showed a bond strength of between 14 and 15 lbs per inch width. Laminator "B" showed a bond strength of 10 to 12 lbs./inch width but was extremely erratic. Laminator "C" showed a bond strength of 8-½ lbs./inch width. Laminator "D" showed a bond strength of 6 lbs./inch width.

The above values are average figures. Test values fluctuate as much as 2 or 3 lbs. over the length of the test.

The Dynamic Mechanical Properties of Epoxy Resins

There is a direct correlation between softening temperature by distortion or penetration, dilatometric glassy transition temperature of epoxy resins, and regions of major dynamic mechanical dispersion.

D. H. Kaelble

Central Research Department
Minnesota Mining and Manufacturing Company, St. Paul, Minnesota

Basic Parameters

The viscous and elastic response of a polymer to a cyclic stress, or strain (varying sinusoidally with time) is termed the dynamic mechanical response. The gross apparent stiffness of a polymeric material at a particular temperature and frequency is measured by the *dynamic (Young's) modulus* (E_R). This gross stiffness factor may be resolved in terms of an elastic and a viscous contribution. The elastic or springlike contribution to total stiffness is termed the *storage modulus* (E_1) and is a measure of the mechanical energy stored and recovered each dynamic cycle. The viscous contribution to total stiffness is called the *loss modulus* (E_2) and is direct measure of the energy dissipated each dynamic cycle and lost primarily as heat.

It is well known that the gross stiffness of a polymer changes with both temperature and cyclic frequency. As the gross stiffness changes so does the elastic (storage) and viscous (loss) contributions to this total stiffness. Characterization of the total stiffness, in terms of these energy storage and loss contributions, and as a function of frequency and temperature, provides information useful to both the research chemist and product engineer.

Figure 1 indicates the manner in which the stress (Curve A) and strain (Curve C) varies with time. In the case of the Maxwell device both stress and strain are tensional-compressional. *The dynamic (Young's) modulus* (E_R) is just equal to the ratio of maximum stress (S_o) divided by maximum strain (γ_o)

$$E_R = \frac{S_o}{\gamma_o}$$

In general the strain wave (Curve C) lags the stress wave (Curve A) by some phase angle (δ). Under these conditions we can divide the stress wave into two components (Curves B) an elastic stress (S_E) which is in phase with the strain (γ), and a viscous stress which is 90 degrees or $\pi/2$ radians out of phase with the strain (γ). The ratio of the maximum elastic stress ($_oS_E$) to maximum strain (γ_o) is termed the *storage modulus* (E_1).

$$E_1 = \frac{{}_oS_E}{\gamma_o}$$

In a similar manner the ratio of the maximum viscous stress ($_oS_V$) to maximum strain (γ_o) is termed the *loss modulus* (E_2).

$$E_2 = \frac{{}_oS_V}{\gamma_o}$$

A characteristic of the decomposition of the stress (S) into its components (S_E) and (S_V) is that the ratio ($_oS_E/_oS_V$) and the corresponding modulus just equals the tangent of the stress (S)–strain (γ) phase angle (δ). This ratio of moduli is termed the *loss tangent* (tan δ)

$$\tan\delta = \frac{E_2}{E_1}$$

A further property of the division of the stress (Curve A) into its components (Curve B) is that the maximum stress is given by the following expression:

$$S_o = ({}_oS_E^2 + {}_oS_V^2)^{1/2}.$$

From this expression and the preceding relations it may be shown that:

$$|E_R| = (E_1^2 + E_2^2)^{1/2}$$

where $|E_R|$ is the absolute value of the dynamic modulus.

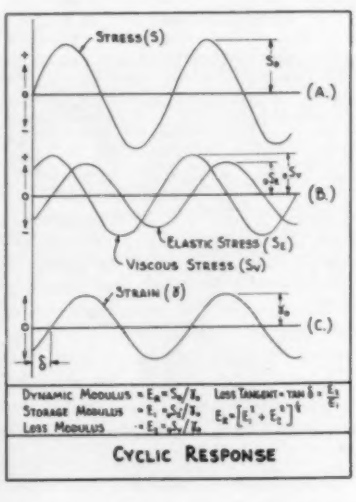


Figure 1. Curves, show how stress and strain vary with time.

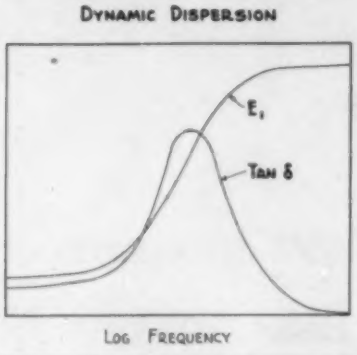


Figure 2. Curves are illustrative of dynamic mechanical dispersion.

The Glassy Transition and Dynamic Mechanical Dispersion

The glassy transition temperature is dependent on the time scale or frequency of the measurement. This time dependency results from the fact that a diffusion rate controlled mechanism is normally associated with the "freezing in" of molecular mobilities in the transition region. A standard procedure for determining the glassy transition temperature is to measure some function of density with change in temperature. In phenol-formaldehyde resins the glassy transition temperature has been associated with the heat distortion temperature and dynamic mechanical dispersion (2).

One of the physical phenomena with which dynamic mechanical measurements are concerned is that of dispersion. Optical and dielectric dispersion are well known phenomena. The features of a mechanical dispersion are:

(a) over a narrow frequency region the dynamic moduli (E_1) and (E_2) drop from higher to lower values as the frequency decreases or temperature increases.
(b) the loss tangent (tan δ) goes through a maximum at the frequency at which the dynamic modulus (E_2) curve has its inflection point, and E_2 goes through a maximum.
(c) the dispersion region shifts to lower frequencies as the temperature is lowered.

In the glassy state it has been shown experimentally that each dispersion region is associated with a specific molecular group (1, 6). As the frequency is increased or temperature lowered this group is "frozen in" and thus contributes to an increase in stress and resulting modulus.

In the region of the glassy transition a number of molecular mobilities are gradually frozen in with increased frequency and lowered temperature. This heterogeneous effect generally leads to a much broadened dispersion region and is described in terms of a continuous spectrum of processes. Here also the change in complex dynamic modulus (E_2) through the dispersion region and maximum tan δ value will be much larger than for a glassy state dispersion region. These properties of dynamic mechanical dispersion are illustrated in Figure 2.

Temperature and Frequency Interdependence

The now standard "method of reduced variables" as applied to mechanical response of amorphous polymers involves two assumptions. The first is that the moduli E_2, E_1, and E_3 are proportional to absolute temperature (T) and density (P), hence:

$$\frac{E_o}{T_oP_o} = \frac{E}{TP}$$

where E_o, P_o and E, P are respectively associated with temperatures T_o and T. Secondly that all molecular mobilities have the same frequency temperature dependence as expressed by the following equation:

$$\log a_T = \frac{0.434A}{R}\left(\frac{1}{T} - \frac{1}{T_o}\right)$$

where A is the activation energy of flow, R the gas constant and $\log a_T$ the logarithmic frequency shift relating temperatures T and T_o.

The "reduced variables treatment" checks well for polymers having weak intermolecular binding forces in the region of the glass transition. In the glassy state it would appear that each mobility may have a discrete activation energy and that the shape of the dispersion curves depend on temperature.

TABLE I. Chemical Reactants

Number	Compound	Equivalent Weight
1	Diglycidyl ether of Bisphenol A	200
2	Boron trifluoride amine complex	—
3	Diethylene triamine	20.6
4	Metaphenylene diamine	27.0
5	Methylene bis(orthochloroaniline)	66.5
6	Aliphatic diamine	158

TABLE II. Formulation and Curing Conditions

Cure Recipe No.	Parts by Wt.		Cure Conditions	
	Resin	Curative	Time (Hr.)	Temp. (°C.)
1-2	100	2	12	132
			24	178
			1	204
1-3	100	10.3	24	R.T.
			2	120
1-4	100	13.5	24	R.T.
			16	120
1-5	100	32.7	24	160
1-6	100	79	24	R.T.
			16	120

Experimental

The diglycidyl ether of bisphenol-A was chosen as the common epoxy base for the several cure compositions. This epoxy was crosslinked catalytically with a boron trifluoride amine complex to produce the homopolymer and coreacted stoichiometrically with four diamine curatives, of varying structure and molecular weight. The chemical reactants and formulation and curing conditions are indicated in Table I and Table II respectively. Specimens for mechanical properties testing were cast in rectangular molds and machined to final shape. Specimens for dynamic property testing were either cast in glass tubes or machined from rectangular shape.

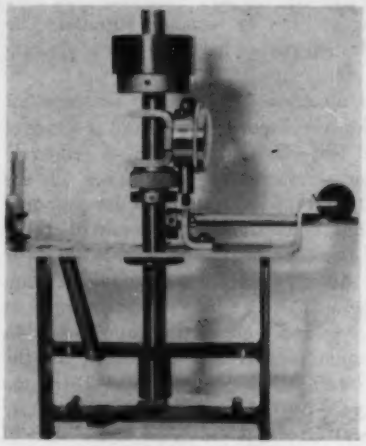


Figure 3.
Test fixtures and specimen for the modified Vicat heat penetration test.

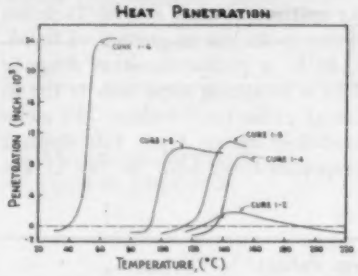


Figure 4.
Curves developed by modified Vicat heat penetration test.

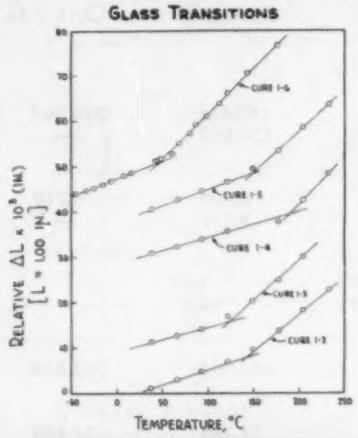


Figure 5.
Expansivity curves are used to give glassy transition temperatures

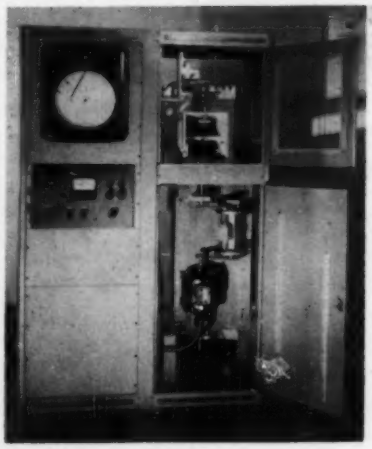


Figure 6.
Maxwell device—useful instrument in the analysis of dynamic properties of epoxy.

The test fixture and specimen for the modified Vicat heat penetration test, as used in our laboratories, is illustrated in *Figure 3*. The test is adapted for use with a standard heat distortion tester. The penetrator head, having a flat penetrator needle of square cross section and 1.0 mm^2 area, attaches to the load shaft. The compression weight is adjusted to a total of 1.0 Kg. The rate of bath temperature rise remains at 2.0°C/min. The test permits semimicro testing of samples of simple geometry and provides a penetration depth versus temperature curve as shown in *Figure 4*. By convention, the intersection of the extrapolated linear portion of the penetration curve to zero penetration is termed the heat penetration temperature.

The glassy transition temperature is obtained from linear expansivity curves as shown in *Figure 5*. The curves are plotted with adjusted base values of ΔL to provide for convenient vertical displacement.

The Maxwell device, as presently developed, is photographically represented in *Figure 6*. No basic modifications of the original sample drive or dynamometer described by Maxwell (7) are made. Addition of a self-regulating d.c. motor drive (Servo-Tek Products Company, Inc.) and planetary mounted gear train assembly provide increased convenience in monitoring and controlling frequency. The dynamometer is provided with means for maintaining near ambient temperature for the strain gages independent of test temperature. A commercial strain gage recorder (The Foxboro Company) provides a stabilized low voltage 1000 c/s power supply and autographic recording. Minor advantages are gained by the vertical arrangement of sample and dynamometer. The present temperature range of the thermostated instrument is −60°C. to 260°C. with a frequency range from 0.003 to 300 c/s.

Results and Discussion

Standard Measurements

The mechanical properties of the five epoxy resin compositions, as measured by standard test methods, are presented in Table III. The Young's modulus of elasticity as measured in tension, compression, and flexure, range from 2.0×10^5 to 5.0×10^5 psi at room temperature. While tensile strengths of 4000 to 9000 psi appear somewhat low, room temperature compressive strengths from 25,000 to 35,000 psi are in the expected range. Rockwell hardness and Izod Impact properties display magnitudes normal for epoxies.

The heat softening and glassy transition temperatures of the cured epoxies are reported in Table IV. A very close agreement for the softening temperatures as measured by ASTM heat distortion and the modified Vicat heat penetration test is noted. The additional information provided by the penetration test is developed from a comparison of the penetration curves as shown in *Figure 4*.

Partansky and Schrader have shown, in measurements of bending deflection versus temperature in the heat penetration test, curves quite similar to those presented in *Figure 4*. The previously reported equilibrium bending deformation above the softening temperature was shown to be reversible and a measure of the elastic stiffness at temperatures above the softening range (8). Referring again to *Figure 4*, it is noted that Cure 1-2 has the lowest maximum penetration, Cures 1-3, 1-4, and 1-5 have roughly equivalent intermediate maximum penetrations and Curve 1-6 the greatest penetration. On the basis of this information it is suspected that Cure 1-2 would exhibit the smallest change in mechanical properties through the softening range and Cure 1-6 the greatest property change. The

modified Vicat penetration test thus supplies two items of information, the temperature of incipient softening, and an indication of the relative stiffness above the softening temperature.

It may be noted, from *Table IV*, that while the glassy transition temperature as measured by thermal expansivity is consistently higher than distortion or penetration temperatures a good agreement between samples is indicated. The coefficients of linear expansion below and above the glassy temperature are nearly identical for all samples tested. From inspection of *Figure 5* the temperature region of non-linearity in expansivity properties is fairly narrow and on either side of this region very linear response is displayed.

It is concluded that the crosslinked epoxy samples examined display a well defined glassy transition temperature. Also the glassy transition measurements made by the heat distortion and penetration tests are in agreement.

Dynamic Measurements

The results of dynamic mechanical property measurement of the five crosslinked epoxies are graphically represented in *Figures 7* through *Figure 11*. The storage modulus (E_1) and the loss tangent (tan δ) are presented on three dimensional plots as functions of test frequency and temperature. The plotting scales for all figures in this series are uniform to facilitate direct comparison of the storage modulus (E_1) and loss tangent (tan δ) response surfaces. The use of solid dots and dashed curves indicates one is viewing a reverse surface.

Figures 7A and 7B illustrate the dynamic response for the BF_3 amine complex catylized epoxy (Cure 1-2) over the temperature range from 25°C. to 180°C. A relatively uniform frequency and temperature dependence of the storage modulus (E_1) and no maximum in loss tangent (tan δ) is noted. It has been shown previously that the temperature region of dynamic dispersion is broadened by increased crosslinking density and shifted to higher temperatures (2). Cure 1-2 exhibits a softening temperature at approximately 120 degrees and a glassy transition at 141°C.

At least two dispersion regions are recognized for the diethylene triamine crosslinked sample (Cure 1-3) in the temperature range from −50°C. to 150°C. A glassy state dispersion occurs at −50°C. and is indicated in the shift of E_1 from lower to higher values with increased frequency in *Figure 8A*. The minor maxima in tan δ at −50°C. is not indicated in *Figure 8B* due to its low magnitude of 0.055. Between 100°C. and 140°C. a glassy transition dynamic region occurs indicated by a maximum slope area in the E_1 response surface and a ridge in the tan δ surface. The metaphenylene diamine crosslinked epoxy, Cure 1-4, displays very stable dynamic properties from −50° to 140°C. Be-

TABLE III. Mechanical Properties of Resin Cures (avg. values)

Property	Method	Cure 1-2	Cure 1-3	Cure 1-4	Cure 1-5	Cure 1-6
Tensile Modulus (psi)	**ASTM**					
23°C.	**D638-52T**	**406,000**	**507,000**	**202,000**	**190,000**	**290,000**
100°C.		**—**	**84,400**	**175,000**	**150,000**	**—**
Tensile Strength (psi)	**ASTM**					
23°C.	**D638-52T**	**4,284**	**6,160**	**9,930**	**8,350**	**4,730**
100°C.		**—**	**5,670**	**9,750**	**7,770**	**—**
Tensile Elongation (%)	**ASTM**					
23°C.	**D638-52T**	**0.11**	**1.35**	**3.00**	**2.23**	
100°C.		**—**	**14.5**	**8.75**	**14.0**	
Compression Modulus (psi)	**ASTM**					
23°C.	**D695-54**	**248,000**	**271,000**	**278,000**	**284,000**	**240,000**
Compression Strength (psi)	**ASTM**					
23°C.	**D695-54**	**35,000**	**32,600**	**32,200**	**34,300**	**24,800**
Compression Strain (%)	**ASTM**					
23°C.	**D695-54**	**41.4**	**50.0**	**44.0**	**42.0**	**57.3**
Flexure Modulus (psi)	**ASTM**					
23°C.	**D790-49T**	**360,000**	**—**	**—**	**—**	**243,000**
38°C.		**—**	**365,000**	**355,000**	**317,000**	**—**
100°C.		**—**	**169,000**	**234,000**	**206,000**	**—**
Flexure Strength (psi)	**ASTM**					
23°C.	**D790-49T**	**7,480**	**—**	**—**	**—**	
38°C.		**—**	**15,100**	**15,500**	**15,200**	**9,110**
100°C.		**—**	**4,230**	**8,570**	**7,060**	**—**
Hardness (Rockwell "L") 23°C.	**ASTM D785-51**	**114**	**118**	**119**	**121**	**87**
Izod Impact (ft. lb./in.) Notched	**ASTM**					
23°C.	**D256-54T**	**0.21**	**0.22**	**0.28**	**0.25**	**0.23**

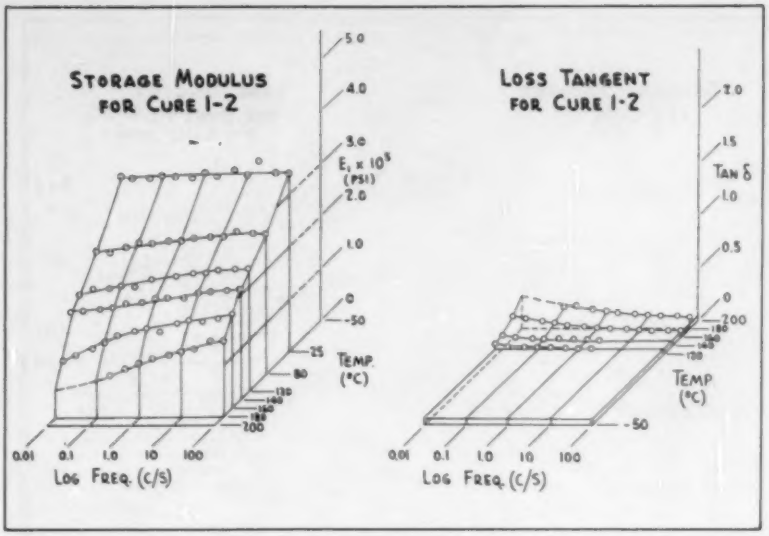


Figure 7 (a & b).
Three-dimensional figures illustrate dynamic response for the BF_3 amine complex catylized epoxy over the temperature range 25 to 180°C.

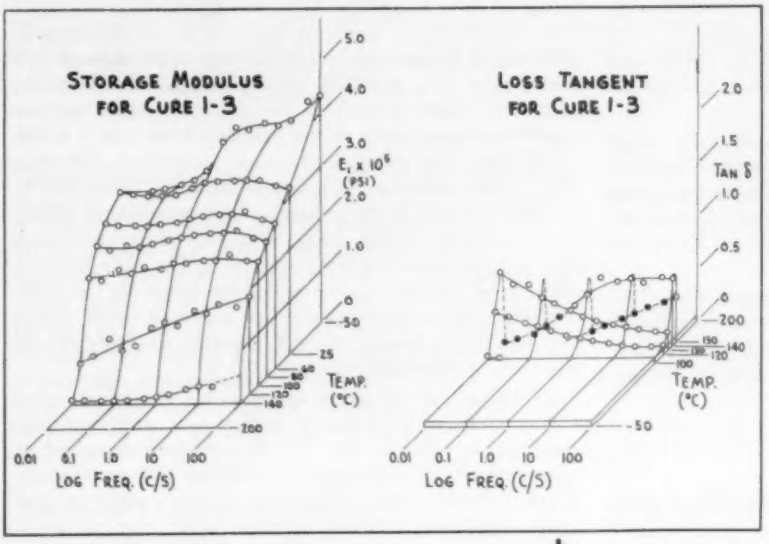


Figure 8.
a. Glassy state dispersion occurs at —50°C. and is indicated in the shift of E_1 from lower to higher values with increased frequency.

b. The minor maxima in tan δ at —50°C. is not indicated due to its low magnitude of 0.055.

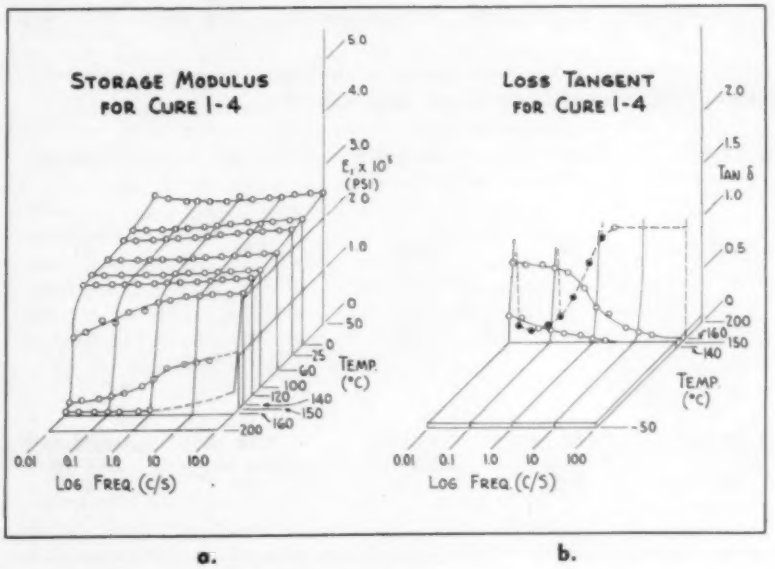


Figure 9.
a. Between 140 and 160°C., a sharp drop in E_1 values occurs.

b. Between 140 and 160°C., peaking in tan δ values is indicated.

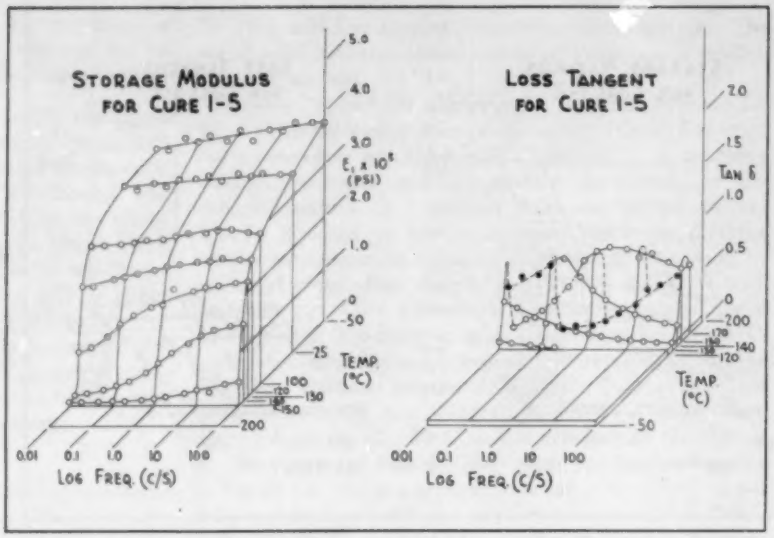


Figure 10 (a & b).
A broad and very well defined glassy transition dispersion region is indicated in the temperature range from 130° to 150°C. by both the E_1 and tan δ response surfaces.

tween 140° and 160°C. a sharp drop in E_1 values and peaking in tan δ values are indicated in *Figures 9A and 9B* respectively.

Cure 1-5, the methylene bis(ortho-chloroanaline) cured epoxy, displays a rather mild slope in the E_1 surface between −50°C. and 100°C. as shown in *Figure 10A*. A broad and very well defined glassy transition dispersion region is indicated in the temperature range from 130° to 150°C. by both the E_1 and tan δ response surfaces.

Figures 11A and 11B, illustrating dynamic response for the C_{36} aliphatic diamine, show the glassy transition dispersion at temperatures between 40° and 80°C. This dispersion displays a high apparent magnitude in the tan δ maximum.

Comparison of Results

In comparing the dynamic response data with thermal property data it is interesting to note that except for Cure 1-2 the temperature ranges of major dynamic dispersion are in good agreement with the observed glassy transition and softening temperatures. Comparing *Figures 7B through 11B* with *Figure 4 a* generally good correlation between the maximum values of tan δ in the transition region and the equilibrium penetration in the modified Vicat test is noted.

The lack of a complete dynamic mechanical dispersion region in the indicated glassy transition region below 180°C. for Cure 1-2 may simply indicate a high crosslinking density combined with strong steric and secondary interaction effects at the molecular level induced by the close knit network. Some weight is provided this conclusion by the measured high tensile modulus and low tensile strength, tensile elongation, and flexure strength reported in *Table III* for the 23°C. test temperature.

In diamine cured epoxy systems the general effect of aromatic diamines producing higher heat distortion temperatures is reflected also in the softening temperature, glassy transition, and dynamic transition dispersion measurement for this series. The rather dramatic effect of adding a long chain aliphatic diamine which may act as an internal plasticizer is recognized in the marked lowering of the transition temperature range and much more pro-

TABLE IV. Thermal Properties of Resin Cures (avg. values)

Property	Method	Cure 1-2	Cure 1-3	Cure 1-4	Cure 1-5	Cure 1-6
Heat Distortion Temp. (°C.) 264 psi	ASTM D648-45T	120	91	131	119	47
Modified Vicat Penetration Temperature (°C.)		125	93	136	123	51
Coef. of Linear Expansion (inch/inch/°C.)	ASTM D696-44					
A. Below Tg		$6.38 \cdot 10^{-5}$	$6.00 \cdot 10^{-5}$	$5.83 \cdot 10^{-5}$	$7.14 \cdot 10^{-5}$	$7.79 \cdot 10^{-5}$
B. Above Tg		$16.4 \cdot 10^{-5}$	$17.9 \cdot 10^{-5}$	$20.8 \cdot 10^{-5}$	$18.5 \cdot 10^{-5}$	$20.0 \cdot 10^{-5}$
Glassy Transition-(°C.)	ASTM D696-44	141	122	190	149	47

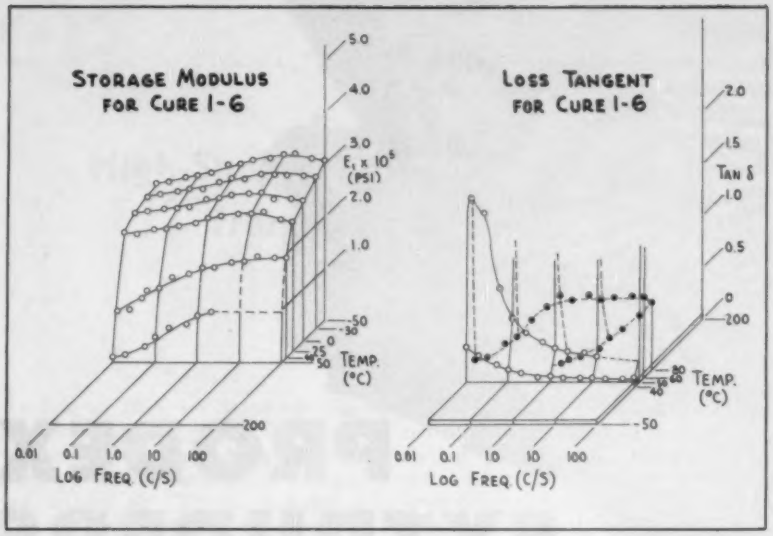


Figure 11 (a & b). Curves illustrate dynamic response for C_{10} aliphatic diamine, show the glassy transition dispersion at temperatures between 40° and 80°C.

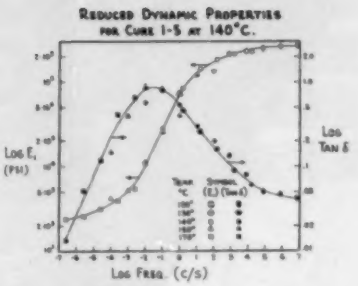


Figure 12. The transition dispersion dynamic mechanical properties of crosslinked epoxies are available for reduced variables treatment in a manner now applied as standard practice to elastomers and amorphous thermoplastics.

nounced dynamic dispersion as gaged by the maximum tan δ values.

The response surface plots of dynamic mechanical properties indicate the values of measurements where both frequency and temperature are varied systematically over broad ranges. Mechanical properties in the glassy state and in the glassy transition region change as a function of both variables. To illustrate this frequency-temperature interdependence, the reduced-variables treatment as described in the introduction is applied to the glassy transition dispersion data of Cure 1-5.

Treatment By Reduced Variables

The superposition of E_1 and tan δ values of Cure 1-5 for five temperatures from 120°C. to 170°C. is illustrated in *Figure 12*. A high apparent activation energy of flow, A = 167 kilocalories/mole, relates the frequency-temperature interdependence for these data. The data are reduced to a reference temperature $T_o = 413°K$. Data, represented in *Figure 12*, are taken at decade intervals and thus represent only one third of the experimental points available for superposition. From *Figure 12* it is recognized that the transition dispersion dynamic mechanical properties of crosslinked epoxy are available for reduced variables treatment in a manner now applied as standard practice to elastomers and amorphous thermoplastics. Information relating to the time distribution of molecular mobilities may be developed directly from analyses of the so-called "master curves" of superimposed dynamic data.

Conclusions

The Maxwell device is useful to the analysis of dynamic properties of thermoset epoxy resins in the glassy state and through the glassy transition region. The unique advantage of this instrument is the broad continuous frequency range.

For the epoxy resins studied here a direct correlation is seen between the thermal softening temperature by distortion or penetration, dilatometric glassy transition temperature and regions of major dynamic mechanical dispersion. The dynamic dispersion analysis over ranges of frequency and temperature would appear to best characterize this transition region.

It is shown that the frequency-temperature reduced variable treatment is applicable to dynamic response of thermoset epoxy resins. Three dimensional plots of dynamic response versus frequency and temperature also provides an effective manner of representing these data.

Acknowledgment

The author is indebted to Mr. G. A. Morneau who cooperated in instrument development and Mr. D. R. Teich who conducted the experiments and performed calculations.

Literature References

1. Deutch, K., Hoff, E. A. W., and Reddish, W., *J. of Poly. Sci.* 13 565 (1954)
2. Drumm, M. F., Dodge, C. W. H., and Nielsen, L. E., Preprint, P. P. & P. Div., ACS, 15, No. 1, 257, April (1955)
3. Eirick, F. R., Rheology, Vol. 2 165, Academic Press Inc., N. Y. (1958)
4. Ibid. 210
5. Flory, P. J. *Principles of Polymer Chemistry*, Chap. 10, Cornell Univ. Press, Ithaca, N. Y. (1953)
6. Hoff, E. A. W., Robinson, D. W., Willbourn, A. H., *J. of Poly. Sci.*, 18 161 (1955)
7. Maxwell, *ASTM Bull.* No. 215, 76, July (1956)
8. Partansky, A. M., and Schrader, P. G. Preprint, P. P. & P. Div., ACS 16, No. 2, 123, Sept. (1956)

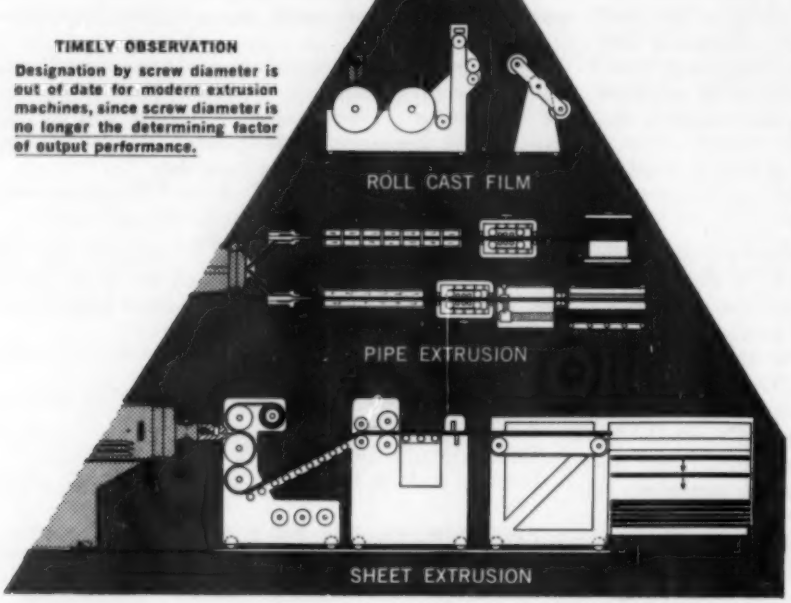
PRODEX EXTRUDERS

AND COMPLETE EXTRUSION SYSTEMS

COST LESS

TIMELY OBSERVATION

Designation by screw diameter is out of date for modern extrusion machines, since screw diameter is no longer the determining factor of output performance.



- They produce more pounds per hour per invested dollar.
- They produce more pounds per hour with higher precision because of their advanced screw design combined with valving—in many cases a two stage screw.
- They cost less in operation and in investment because of higher horsepower efficiency. PRODEX EXTRUDERS convert a higher percentage of available horsepower into useful output. Higher production rates are obtained with smaller motor drives.
- They cost less in maintenance because of their rugged construction. They are built to operate around the clock, year in and year out.

Before you buy another extrusion machine, investigate the extraordinary PRODEX. It is most likely that your production requirements will be fulfilled by a PRODEX EXTRUDER one size smaller. We will gladly demonstrate this to you with your own material in our customer service laboratory. Telephone or write us for an appointment.

Complete PRODEX EXTRUSION SYSTEMS are available for sheet, roll cast film, pipe, wire and cable, compounding. Prodex extruders are available in sizes ranging from 1¾" through 8" with L/D ratios of 20: 1, 24: 1 and longer...with or without venting.

Write for illustrated bulletin E-6.

PRODEX CORPORATION

FORDS, NEW JERSEY · Phone: HILLCREST 2-2800

IN CANADA: Barnett J. Danson & Associates, Ltd., 1912 Avenue Road, Toronto 12

Licencee for European Common Market and Austria...HENSCHEL-WERKE GMBH KASSEL, W. GERMANY

PRODEX —in design and performance ALWAYS A YEAR AHEAD

Speaking of Extrusion

High-Speed Production of Clear Film from High Density Polyolefins —A Progress Report

Water-quenched polyolefin films can be produced at high speeds

ROBERT DOYLE and C. V. DETTER

PHILLIPS CHEMICAL COMPANY
BARTLESVILLE, OKLAHOMA

In June of 1958, we described (Ref. 1) a water quench process for the extrusion of clear film from high (0.96 density) polyethylene. In a December article (Ref. 2), we included a 0.95 density ethylene/butene copolymer, also produced by the Phillips polyolefin process, as another resin which gave excellent results by the same technique. Each of these articles promised further reporting of anticipated process improvements. Meanwhile, a number of articles on "chill roll" film have appeared from other sources. Some of these state that water carry-over severely limits production speeds for supposedly any polyethylene film produced by the water bath method. It has become increasingly apparent, therefore, that we should publish a report of the changes and improvements achieved with the semi-production scale unit described in our initial article.

Equipment Changes

With the same 2½" extruder and screw described in Ref. 1, we are now able to utilize the full output of the machine at 100 r.p.m. or about 140 lbs./hr. This exceeds our previous estimate of 1 ¼ lbs./hr./r.p.m. However, the output of the extruder rather than water carry-over still determines our maximum lineal speed for any particular film thickness.

Our original T-die, with flat external faces and extended die lips projecting just below the bolt heads, has stood up as the best design yet evaluated. Other designs encountered in the field have had built-in heat or gauge control problems. Many V-face, laminating type dies lose so much heat from the exposed metal faces that operating temperatures must be increased excessively to compensate for the losses. On these and other dies, massive die blades with large adjustment bolts, widely spaced across the die, lack the adjustability required for good gauge control. Also, since the internal streamlining needed for vinyls is not needed here, "fishtail" designs may create more problems than they theoretically might solve.

Other than upping the entire speed range of our wind-up to more than double its original limits, the only real change made in our equipment layout was a modest change in the water tank. By going from two to three idlers in the tank as shown in *Figure 1*, we avoid wrinkling problems at high speeds. Also, we were able to move the first roll which the film contacts to within 1" of the water surface while still providing the length of underwater travel required for cooling. There are indications that, with the first roll as close to the surface as possible, a somewhat glossier film results.

Each of these three rolls is equipped at each end with a matched set of impellers, one of which is illustrated in *Figure 2*. The impellers circulate the water through the rolls, maintaining them at the same temperature as the bath. These impellers were in the original two rolls but they apparently assumed more importance in the first roll at its new location.

For successful high-speed operation, adequate water circulation through the bath is an absolute necessity. The water should be changed *at least* every five minutes, i.e., a 50-gallon tank should be fed by a pump with effective delivery of not less than 10 gal./min. This water should be distributed along one or two sparger pipes as shown in *Figure 1*. The pipe underneath the web should be directed at roughly 30° down from the horizontal and toward the back wall of the tank for slow speed operation (up to 200 ft./min.) or shifted up to about 60° above the horizontal and still toward the back

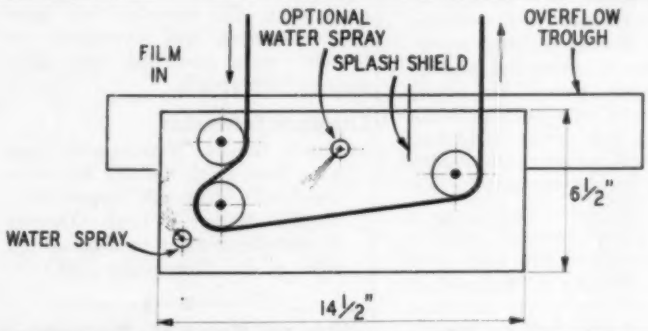


Figure 1—Schematic Cross-Section of Water Bath.

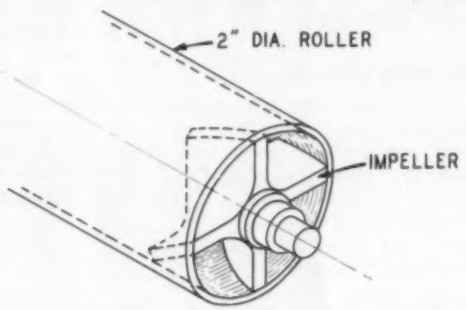


Figure 2—End View of Water Bath Idler Roll.

wall for higher speeds. The optional pipe within the "U" formed by the web travel may usually be directed at 45° down from the horizontal and toward the back wall, at all speeds. Under no circumstances, however, should a turbulence be created on the surface of the bath since this mars the surface of the film and may even tear off the web entering the water.

As we pushed for higher speeds, we found white deposits on the film which we attributed to known hardness of the water. Nevertheless, we were unable to eliminate this defect by connecting a variety of household water treating, units into the system. Observing that the white deposits were always associated with equally undesirable scratches in the film, we replaced an existing treating unit with a simple 10-micron filter cartridge (Cuno 2278-Cl) in the incoming line to the tank. This filter removed the small amount of fine rust and scale which had been scratching the film. With the scratches gone, the hardness deposits no longer collected.

The web leaving the bath should be led directly upwards, perpendicular to the water surface, to minimize water pick-up. The water then carried up can be held back from further travel with a pair of squeeze rolls, *both* covered with 45 durometer, heat resistant synthetic rubber. Silicone rubber is not required. These rolls should be as close to the water as possible with their axes in a horizontal plane. Leaving the squeeze roll nip, the web should continue in the same direction in which it entered, i.e., with no wrap whatsoever on either roll. Otherwise, the web may start to pick up water which the rolls have just removed.

Under these conditions, we have shown that film speeds of 440 ft./min. are practical *without water carry-over*. With a larger extruder plus a suitably designed wind-up, still higher speeds appear to be feasible. Of course, as many others have undoubtedly found, the ultimate in electronic tensioning control is a prime requisite for good, high-speed operation with any light gauge, plastic web.

Processing Changes

In going to higher operating speeds, we have found that the optimum stock temperature range is a little lower than that we reported for slower speeds. We now operate with a stock temperature of between 400° and 440°F for maximum gloss and freedom from "comets" and "pock marks" at high speeds. This new, lower range is applicable to both MARLEX Resins Nos. 6050 and 5065. As before, however, the die lips *must* still be within ¼" of the water bath surface.

In addition, we have gone to a somewhat finer screen pack (20/80/100/120/150/80/20) and a slightly smaller (0.018") die opening. This new die opening seems to be closer to an optimum compromise between the ease of operation resulting from a lower draw-down ratio and the glossier film achieved with higher ratios. Apparently, a combination of quick quenching *plus* a high degree of orientation is required for optimum gloss and clarity.

We have also changed over to razor blade slitting of the trim to simplify the problem of maintaining sharp cutting edges in our own particular operation.

Our experience has been that it is actually easier to operate this process at high speeds than at slow speeds. For example, it is easier to get the die close to the water since the meniscus around the web is inverted at high speeds. More important, an even clearer and more sparkling film is produced at high speeds.

The only peculiar problem we have noted is that high speeds may pull so much water up to (but *not* past) the squeeze rolls that the level in the tank is significantly lowered. The tank must then be elevated to maintain the required ¼" gap but this change in position must be kept in mind whenever the line speed is reduced. Otherwise, as the volume of water returns to the tank with decreasing speeds, the die may become submerged.

Treating for Printing

While not mentioned in our initial article, we have been investigating inline treating for printing on our equipment, using known oxidation procedures. Since the high density polyolefins are less easily oxidized, more stringent treating conditions are needed. Nevertheless, we have attained acceptable ink adhesion properties at production speeds up to 300 ft./min. and confidently expect to raise this maximum with further modifications in the treating equipment. Incidentally, successful treating at these speeds should be ample proof that water can be completely removed from high density polyolefin film run through a water bath at high speeds under proper conditions.

We are presently employing a commercial Lepel treating unit, a "Mylar"-wrapped roll and a ¼" wide carbon steel electrode bar radiused at the face to conform to the curvature of the wrapped idler roll. By increasing the treating *area*, i.e., *time* for treating, acceptable treating can apparently be attained at any practical, commercial speed. Voltage and amperage, as such, are of secondary importance to available treating area.

At the same time, it should also be pointed out that the high density polyolefins specified at the outset of this article are inherently non-blocking in nature. Hence, no lubricants or similar agents are added which might "bloom" to the surface to interfere with post-extrusion treating. For this reason, film from these resins may be successfully treated at any time after extrusion, i.e. during slitting, etc.

Cast Film Process

We have already demonstrated that high density polyethylene and ethylene copolymer films can be water-quenched at speeds up to at least 440 ft./min. *without* water carry-over. Hence, the reported speed limitation of the water bath process has certainly not been encountered in our work.

On the other hand, the cast film process, as presently developed, is limited by such problems as "puckering" or a "seersucker" effect. Currently, maximum rates for any cast polyethylene film, *free of puckering*, seem to lie between 50 and 150 ft./min., depending on the source of the information.

Conclusion

We have shown that high-speed production of water-quenched film is entirely practical. Those considering the installation of casting roll equipment should note that an alternate water bath set-up can be inserted between the extruder and the wind-up at a relatively small additional cost. Many existing installations could also be modified very reasonably. The net result will be an increased diversity of potential outlets, extending over into a tremendous overwrap market now almost completely dominated by cellophane. Rapid advances in sealing techniques and packaging equipment will soon make a sizable segment of that overwrap market available to film extruders who have the equipment and experience to handle water-quenched polyolefin films at high speeds.

Literature References

1. Doyle, Robert, "Extrusion of Clear Film from High Density Polyethylene", SPE J., p. 35, (June 1958).
2. Doyle, Robert, "High Density Polyethylene Film in Packaging", ibid., p. 44 (December, 1958).

—■—

edited by **Bruce H. Maddock,** *Union Carbide Plastics Co.*

National Action

AN OPEN LETTER TO NON-MEMBERS

On behalf of SPE members and their National Officers, allow me to extend a most cordial welcome to this 16th Annual Technical Conference (ANTEC).

We hope you will join us sharing your desire to learn with others like yourself. It is our purpose to present here the best technical program that it is possible to assemble. We have a powerful, continuing interest in these technical matters, and it is this that leads us to band together as a Society—The Society of Plastics Engineers, Inc.

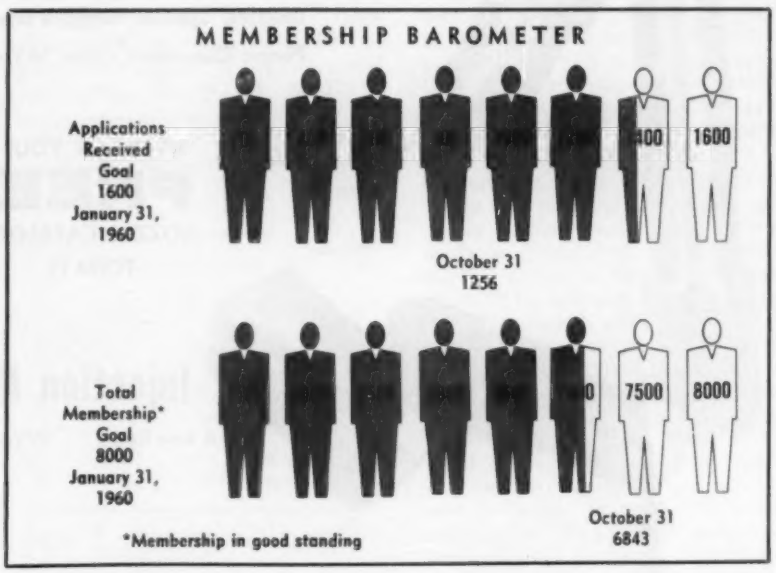
We seek to share technical information in the broad field of plastics. To accomplish this, the SPE Journal, an outstanding technical magazine is published; books on all phases of the plastics industry are written and published; technical meetings such as this are sponsored, and monthly meetings of strategically-located Membership Sections are also held.

We believe that you would like to join with us in this endeavor and we should welcome your active participation. (We also have the feeling that your membership helps you boost your professional stature and thus helps you help yourself!) A copy of our membership brochure "What SPE Can Do For You" will explain our basic aims and how you will find your place in SPE. I urge you to read this informative booklet, and fill out the application blank at the back of the book. As a member, your contacts in the plastics industry are literally international in scope!

At this Conference, Council has authorized me to apply a portion of your non-member registration fee to pay your membership initiation fee! Here's where you can get the benefits of SPE and save money too! To take advantage of this offer, just seek out the Membership Area anytime during the Conference, tell us you've decided to join and we'll take care of the details!

Once again, welcome to the ANTEC. Drop in to see us at the Membership Area.

James R. Lampman
National Membership Chairman



edited by **Thomas A. Bissell**
SPE Executive Secretary

SHORT OR TALL
. . . we make them all!

World's largest stock of injection machine nozzles

SHIPPED RIGHT NOW . . . PHONE YOUR ORDER!

. . . . . and we mean it, a call has your nozzle on its way in five minutes! If it's a "special" just phone in the details, it will be in the shop tonight . . . machined . . . heat treated and shipped to you, usually in 3-4 days.

Be sure with IMS QUALITY NOZZLES. Code-dated for your protection, with Rockwell C Hardness etched on every hex.

CUT YOUR PRESS DOWNTIME

We do not sell cut rate nozzles because press downtime costs you more than the few extra cents needed to get an IMS QUALITY TOOL STEEL REPLACEMENT NOZZLE!

IMS Independently Designed Nozzles are better, last longer and cut your injection molding costs. We specialize in Uniform Design Extension Heated Nozzles to save you money.

Send for our Stock Heater Band List today!

WHATEVER YOUR REQUIREMENTS

Heated nozzles, Mixing nozzles, Nylon nozzles, Standard nozzles, Special Purpose nozzles, Flat Nose nozzles, etc.

Phone Cleveland, Ohio, WYoming 1-1424.

SEND FOR YOUR
FREE
NOZZLE CATALOG
TODAY!

Injection Molders Supply Co.

3514 Lee Road WYoming 1-1424 Cleveland 20, Ohio

Molding Cycles

Increasing Plasticating Capacities of Injection Molding Machines

D. L. PETERS and J. N. SCOTT
PHILLIPS CHEMICAL CO.

Special nozzle reduces cycle time requirements

Non-uniform stock temperatures have long been recognized as a major cause of molding difficulties (1, 2, 3). This is particularly a problem with the high specific heat crystalline resins such as linear polyethylene. One of the major problems associated with non-uniform melts is the presence of unplasticated pellets in the molded part. These unmelted particles appear as clear or translucent areas often referred to as "windows". These "windows" detract from appearance and physically weaken the item. Unplasticated pellets have been observed in melts so hot that the resin was actually degrading. This would indicate an extreme temperature spread from below the softening temperature of 260°F to at least 625°F. Other undesirable defects of non-uniform stock temperatures include warpage, brittleness, weld lines, discoloration and poor surface.

Examples

The problems are most often encountered where cycles are short and the weight of the part represents a relatively high percentage of the rated machine size. This indicates that the ability of the heating cylinder to produce an uniform melt is being exceeded even though it may be rated for a much higher maximum output. For example, a typical machine rated at 45 lbs./hr. will produce 3 lbs./hr. of relatively uniform melt; a cylinder setting of 400°F gives an average stock temperature of approximately 390°F. However, at 10 lbs./hr. the average melt temperature drops to approximately 362°F and unplasticated pellets begin to appear. It is evident that an extreme spread in melt temperature exists even though the throughput is less than ¼ the rated capacity of the equipment. The unplasticated material limits the useful rate to less than the 10 lbs./hr. at this temperature setting.

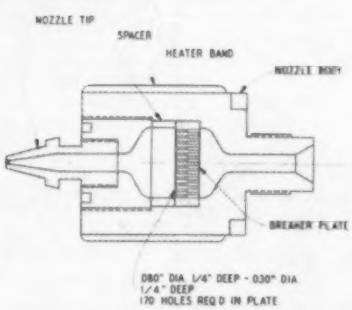


Figure 1—Special nozzle containing breaker plate.

The apparent discrepancy in rated capacity versus practical output is due to the customary method for rating the plasticating capacity of molding machines and the fact that most equipment ratings are based on noncrystalline materials such as polystyrene. Heating cylinders are usually rated at the maximum lbs./hr. throughput of 400°F resin using a maximum cylinder temperature setting (approximately 700°F). This method, although widely accepted, gives values that are not realistic if product quality is to be maintained. It is evident that a wide temperature spread must exist where the heat source is 700°F and the average resin temperature is 400°F.

From these observations, it was apparent that *usable* plasticating capacities of an injection molding machine could be greatly improved by reducing the spread in melt temperatures. It would be desirable to heat the low temperature resin without appreciably affecting the material that was already near the cylinder setting. Our approach to this problem was the development of a special nozzle designed to restrain and heat unplasticated pellets and low temperature melt while allowing hotter resin to pass freely into the mold. This nozzle contained a breaker plate with stepwise reduction in the diameter of the

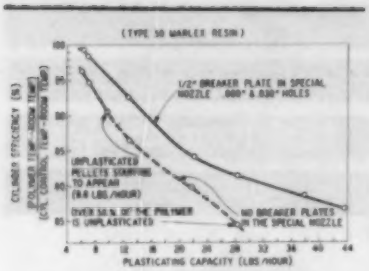

(TYPE 50 MARLEX RESIN)
1/2" BREAKER PLATE IN SPECIAL NOZZLE .080" & .030" HOLES
(UNPLASTICATED PELLETS STARTING TO APPEAR (9.8 LBS./HOUR)
OVER 50 % OF THE POLYMER IS UNPLASTICATED
NO BREAKER PLATES IN THE SPECIAL NOZZLE
PLASTICATING CAPACITY (LBS/HOUR)

Figure 2. Plasticating capacity vs. cylinder efficiency using a 400°F cylinder control temperature

holes to restrain more viscous material and reduce the cross-section to where the resin could be heated rapidly. A large multiplicity of these holes were used to permit the higher temperature more fluid resin to pass through the plate with little restriction.

Special Nozzle Contains Breaker Plate

The nozzle used for this work is shown in *Figure 1*. It was 3½" O.D. and 3½" long with 2.34" diameter throat to receive the breaker plates. A variety of plates containing 170 geometrically spaced holes were evaluated. The body of the nozzle was maintained at the cylinder temperature setting by a 550 watt heater band.

Plasticating capacity, heating cylinder efficiency, melt temperature uniformity and pressure drop data were obtained on a variety of breaker plates in the special nozzle. In this article, we will discuss the improvement obtained with an effective breaker plate. This effective breaker plate had two step holes with the resin entering an 0.080" opening and passing through a .030" exit. The diameter and land length of these exit holes were found to be very critical.

A Type 50, Series 6000 MARLEX polyethylene resin was used for this work.

The plasticating capacity and efficiency were measured according to a method developed by Beyer and Dahl (4). This procedure consisted of purging at various throughput rates for a given length of time, converting the weight to lbs./hr., measuring the average stock temperature and calculating the heating efficiency by the following formula:

$$E = \frac{T_s - T_o}{T_i - T_o}$$

Where: E is the heating cylinder efficiency

T_s is the average temperature of the extruded polymer as measured by a stock temperature thermocouple located in the nozzle

T_i is the control temperature of the heating cylinder.

T_o is the initial temperature of the polymer.

The efficiency (E) was then plotted against the throughput rate of the heating cylinder.

As can be seen from the data in *Figure 2* the usable plasticating capacity of this machine at this temperature was increased from less than 9.8 lbs./hr. to greater than 43.4 lbs./hr. With no breaker plates in the nozzle, fragments of unplasticated resin were observed at 9.8 lbs./hr. and at 26.2 lbs./hr. the purged material was predominately unplasticated. With the breaker plate in the nozzle, no unmelted resin was observed even at the 43.4 lbs./hr. rate.

These data in *Figure 2* also show that efficiency was considerably improved at any given throughput rate. This is believed to reflect improved melt temperature uniformity.

The pressure drop resulting from the breaker plates in the nozzle was measured using a spiral flow mold. The resin flow was measured at several injection pressures at a standard set of molding conditions. The flow obtained with no plates in the nozzle was considered maximum (100%), and the flow obtained with the breaker plates is reported as a per cent of these values.

As can be seen from *Figure 3* the increase in plasticating capacity was accomplished with little pressure drop. The plate described and used to obtain the data in *Figure 2* resulted in only 7.5% pressure loss. A larger number of holes in the breaker plate will decrease this pressure drop and at the same time improve efficiency.

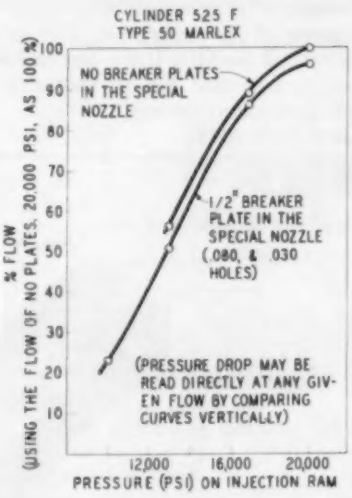

CYLINDER 525 F
TYPE 50 MARLEX
NO BREAKER PLATES IN THE SPECIAL NOZZLE
1/2" BREAKER PLATE IN THE SPECIAL NOZZLE (.080, & .030 HOLES)
(PRESSURE DROP MAY BE READ DIRECTLY AT ANY GIVEN FLOW BY COMPARING CURVES VERTICALLY)
% FLOW (USING THE FLOW OF NO PLATES, 20,000 PSI, AS 100 %)
PRESSURE (PSI) ON INJECTION RAM

Figure 3. Pressure vs. flow.

Cycle Time Reduced

The practical application of this type nozzle not only results in improved product but considerably reduces cycle time requirements. Taking advantage of the higher capacity that this nozzle provides and the lower stock temperatures that can be used, production rates have been dramatically improved. *For example, the cycle requirements for a small 1 oz. bowl molded on a 3 oz. machine was reduced from 19 to 9 seconds.* In another example, the requirement for molding a part containing a 1" cubical section was reduced from 4 minutes to 45 seconds by using this nozzle. Improvement is most pronounced where the machine capacity is being taxed or where heating efficiency requirements are critical.

As is evident from these results, the usable capacity, cylinder efficiency and melt temperature uniformity are greatly improved by the addition of an inexpensive breaker plate nozzle. Production rates can often be remarkably improved as a result of increased machine capacity and the ability to use lower stock temperatures without encountering unplasticated material.

Literature References

(1) Beyer, C. E., Dahl, R. B., and McKee, R. B., "The Injection Molding Machine Heating Cylinder", *SPE Technical Papers*, Vol. 1, January, 1955, Page 347.

(2) Morse, A. B., "Vented Reverse Flow Heating Cylinders", *SPE Technical Papers*, Vol. V, January 1959, Page 20-1.

(3) Bird, A. L., and Eveland, Joe, "Uniformity Consideration for Stock Temperatures in Injection Molding", *SPE Technical Papers*, Vol. III, January 1957, Page 180.

(4) Beyer, C. E., and Dahl, R. B., "Measurement of Heating Capacities of Injection Molding Machines", *Modern Plastics Magazine*, September, 1952, Page 124.

edited by **L. Paggi,**
E. I. du Pont de Nemours & Co., Inc.

Committee Reports

17 COMMITTEES REPORT AT OCTOBER COUNCIL MEETING

At the October 26 meeting of SPE Council, 42 Councilmen heard reports of most of SPE's standing and ad-hoc committees and acted on their recommendations. Highlights of these reports and action follow:

AD HOC COMMITTEES

Educational Campaign to Publicize Institute (American Plastics Institute Committee, Ralph L. Mondano, Chairman)

Council approved the Committee's request for funds for an educational and publicity campaign to influence favorably toward the proposed American Plastics Institute key people in the plastics and related industries.

The program will include an industry-wide questionnaire to ascertain the extent of interest and needed research projects. Council also voted to change this Committee from an ad-hoc to a standing committee.

In its request the Committee made clear that the Institute must ultimately be completely independent if it is to succeed. In assisting to initiate the Institute, SPE will be fulfilling its objective of promoting scientific and engineering information relating to plastics.

If this campaign succeeds in its objective, the need for an American Plastics Institute will be firmly established in the plastics industry, suitable research projects will be selected, and strong support will be available.

At that point, Phase 2 of the program will be initiated—solicitation of funds from industry necessary to make the Institute self-supporting and completely independent. More complete information on the proposed American Plastics Institute may be obtained on request to the Committee Chairman, Ralph L. Mondano, c/o Raytheon Co., Plastics Plant, P.O. Box 25, Maynard, Mass.

Rule Resolves Section Ad Problem (Committee on Advertising in Section Publications, C. H. Whitlock, Chairman)

In adopting as part of a Rule, the recommendations of this Committee, Council took a giant step toward solving a sticky long-standing problem. The Rule authorizes acceptance of advertising that meets the following requirements for Section publications:

1. The advertisers must be located within the Section's geographical area.
2. Advertising cannot be accepted from organizations or their employees or representatives that are classed for purposes of ANTEC registration as:
   a. Primary Material Suppliers
   b. Allied Chemical Suppliers
   c. Heavy Machinery Suppliers

In the remainder of the Rule (mailed to Sections in October by President Frederick C. Sutro, Jr.,), Council encourages Sections to publish Newsletters since they maintain interest and create unity in the Section; gives suggestions as to content and format; and defines circulation.

Standing Committees

Buildings PAG to Sponsor Exhibit (Plastics in Buildings PAG; Frank W. Reynolds, Administrator; Ronald J. Carney, Chairman)

Council voted a green light to the Plastics in Buildings Professional Activity Group to sponsor a traveling educational exhibit.

According to the plan developed by Armand G. Winfield, Chairman, Exhibit Subcommittee of PIBPAG, the exhibit

ISO/TC 61 Forms Specs Group at Munich

(Norman Skow, SPE representative on Committee TC 61 on Plastics, International Standards Organization)

At its annual meeting held in Munich, Germany, October 26-31, 1959, ISO/TC 61 Committee on Plastics launched Working Group 9, headed up by Switzerland, to develop specifications for plastics products. Its first assignment is to develop specifications for:

(a) phenolic molding compounds
(b) rigid PVC compounds
(c) industrial phenolic laminates

With the expanding markets available in Europe to the American plastics industry, the American delegation (U.S. National Committee, ISO/TC 61) believes it important that it have a voice in establishing constructive plastics specifications.

To assist me, as your SPE representative, in achieving this result, I have asked Council to provide assistance from qualified members, particularly with respect to phenolic molding and rigid PVC compound specifications.

will consist of 25 to 30 technical displays contributed by industrial companies. Each unit will cover applications of plastics in the fields of architecture, building, interior decoration, and art, with emphasis on their engineering aspects. The tentative travel schedule calls for a two-year itinerary to 15 museums, universities, and architectural centers throughout the country, the exhibit at each institution lasting about six weeks. The technical exhibit is planned on a self-liquidating basis. Sale of a catalogue-type publication and maintenance fees from exhibitors are calculated to defray operating expenses.

The exhibit was approved by Council only after Administrator Reynolds had reported that the proposal had been checked with the Society of Plastics Industry, the Building Research Institute, and the SPE Public Relations Committee, and no duplication of effort was found or objections made.

Section Scholarship Plan & College Survey Approved (Education Committee, Jules W. Lindau III, Administrator; C. C. Winding, Chairman)

A plan for awarding of Scholarships by Sections was adopted as a Rule by Council upon recommendation of the SPE Education Committee.

The Rule will apply to all new Scholarships awarded by Sections. Highlights:

- Recipients shall have completed at least two years of study for a technical degree, and shall be in need of financial assistance.

- Each recipient shall be selected by the Section from a candidate or candidates recommended by the designated college.

- Awards shall be identified with the sponsoring Sections; shall be at least $250 per school year; may be renewed if the student remains qualified; and shall be given through the designated college.

- Selection of the college shall be made with the help of the Education Committee.

SPE Sections desiring assistance in the development or operation of scholarships are requested to write to: C. C. Winding, Chairman, Education Committee, c/o School of Chemical Engineering, Cornell University, Olin Hall, Ithaca, N. Y.

A second Education Committee project approved at this Council Meeting is a survey of educational institutions to obtain accurate information on the polymer courses offered. Funds were made available to get the job done.

ISR Activity Expanding at Home and Abroad (Inter-Society Relations Committee, Jules W. Lindau III, Administrator; Jerome L. Formo, Chairman)

Relations with foreign plastics societies are just as important to the SPE as those with American societies, and suitable liaison should be established with the Plastics Institute of Great Britain, and similar organizations in France, Italy, and Germany. The foregoing is the major recommendation made in the Committee report. It was reported that contact has already been established by Chairman Formo with NTO, the National Technical Organization of Poland.

Liaison between the SPE and ACS has been particularly active due to the efforts of Irvin Rubin and Russell B. Akin, SPE and ACS, Liaison Chairmen, respectively. Because of the many members and interests that the two Societies have in common, they have been exploring the possibility of extending the present national liaison organization to the regional and section levels. Results envisioned might be joint meetings, mutual assistance in technical programs, exchange of meeting notices, technical programs, and information on student membership activities. The same need to work together on section levels was emphasized again in the report of liaison with Society of Corrosion Engineers.

John B. Howard, SPE Liaison Chairman with ASTM Subcommittee XXI, D-20 ISO Unit, reported that D-20 is on record as favoring the use of metric units in plastics specifications and, thus, in the daily work of plastics engineers. The main advantage, of course, is to put our Country in step with the rest of the civilized world which uses the metric system and thus, to promote America's world trade. There is no thought of an over night change, but rather of laying the groundwork for a gradual change with normal obsolescence.

Activities of the Manufacturing Chemists Association were summarized by George Flanagan, MCA Liaison Chairman:

- A test program on the suitability of plastics for lighting fixtures show that styrene, acrylic, and vinyl chloride plastics, in the form of egg crate or flat sheet, present no undue flammability hazard.

- MCA is sponsoring a one-year study of fire hazards of plastics in building as related to codes at the Southwest Research Institute.

- An MCA Subcommittee will explore with Underwriters Laboratories a project on which the Laboratories would collect basic data on plastics used in appliances and other electrical devices.

A Speakers' list put out by the American Society for Quality Control has been made available to SPE by Gordon K. Storin, SPE Liaison Chairman with ASQC.

William Lewi, who represents SPE's membership on the ASA Council, reports that Norman Skow will serve as his alternate and that the ASA Bulletin is being sent to 15 SPE Officers and key members.

Improved Handling Reported for ANTEC Papers (Publications Committee—Frank A. Martin, Administrator; E. C. Quear, Chairman)

All 16th ANTEC papers to be published in the SPE Journal will have been reviewed by the Editorial Advisory Board by January 1 and the authors will be so notified before ANTEC, according to the Committee report accepted by Council. At the same time, authors of ANTEC papers not selected for Journal publication will be notified that their papers are released for publication elsewhere. The April 1960 issue of the SPE Journal will feature selected ANTEC papers.

New SPE Journal features reported include a new cover design starting with the January 1960 issue; a technical summary of ANTEC to be written by Dr. Jesse H. Day, Journal Editor Emeritus; and an improved SPE Roster that lists members' companies and company connections.

Sections Manual Nearing Completion (Sections Committee—Administrator, George W. Martin; Chairman, G. Palmer Humphrey)

A voluminous first draft of the Sections Procedures Manual is the result of several recent meetings of this Committee and considerable interim work by its members. A staff editor is now assisting the Committee in boiling down and editing this material to produce an effective guide to assist Officers in the organization and operation of their Sections.

—■—

About Members

Robert T. Wallace, a member of the Toledo Section, has joined Owens-Illinois's International Division as a vice president of the division's Panamanian subsidiary, Owens-Illinois International, S.A. Mr. Wallace will devote his time to new foreign investments and licensing and agreements in the Western Hemisphere.

Edward J. Babis has joined Interplastics Corp. as Vice President and Assistant Treasurer. Mr. Babis is a member of the New York Section.

Howard G. Nadell recently joined Irwin L. Podell, Inc. as a consultant for the plastics and chemicals industries. Mr. Nadell is a graduate of City College of New York and is a member of the Newark Section.

Philip R. Scarito has been appointed Vice President in charge of compounding and calendering at Cary Chemicals, Inc., East Brunswick, N. J. Mr Scarito is a graduate of Phillips Andover Academy and The Massachusetts Institute of Technology.

Theodore S. Lawton, Western New England Section, has been appointed an associate in the development department of Monsanto Chemical Company's Plastics Division, Springfield, Mass. Lawton has been director of market development since 1958. He joined Monsanto's Plastics Division here in 1939 as a chemist following graduation from Rensselaer Polytechnic Institute with a B.S. in Chemical Engineering.

C. S. Terry was appointed Molding Engineer with the Sales-Service group of Marbon Chemical Division of Borg-Warner Corp. Prior to joining Marbon, Mr. Terry was for 19 years associated with the American Plastics Corp., a division of Heyden-Newport Chemical Co. He is a member of the Binghamton Section.

Mr. Irving Silver, Baltimore-Washington Section has been named Branch Engineer of the Propulsion Branch in Surface Weapons Systems (Guns, Rockets and Guided Missiles) Division of the Bureau of Ordnance, Department of the Navy. He was formerly with the Naval Ordnance Laboratory at Silver Spring, Maryland, as Division Chief of the Non-Metallic Materials Division. Mr. Silver received his B.S. in Chemistry from CCNY in 1937.

Dr. Elliott S. Pierce, a member of the Board of Directors of the Baltimore-Washington Section, has been appointed Research Administrator in the Directorate of Chemical Sciences in the Air Force Office of Scientific Research. This office supports fundamental research for the Air Force.

Dr. Pierce received his B.S. from Yale in 1943 and his Ph.D. in Organic Chemistry in 1951. He taught Theoretical and Organic Chemistry at the University of Mass. in the school year 1950-1951. He went with American Cyanamid in 1951 where he researched in the relationship of physical properties to organic structure. He served as the Washington Technical Rep. of Cyanamid from June, 1956 to October, 1959.

Philip R. Scarito

Arthur E. Bush

Arthur E. Bush, Upper Midwest Section, has been named president and treasurer of Premier Plastic Manufacturing Co., Inc., St. Louis Park, Minn. Mr. Bush formerly was owner of the company. The company is a custom and production fabricator and designer of plastic sheet material.

NOW . . . A NEWER AND BETTER PRESS

KM Hydraulic Presses are the most improved and finest of their kind. Learn about the many features of our different models. For complete information and illustrated brochure write to:

K-M HYDRAULIC PRESSES

KINGSBACHER-MURPHY CO., 9830 BELLANCA AVE., LOS ANGELES 45, CALIF.

Book Reviews

PHYSICAL PROPERTIES OF POLYMERS

Papers given at Symposium in London (S.C.I. Monograph No. 5) 1959. 293 pages

This book consists of the papers read at the Silver Jubilee Symposium organized by the Plastics and Polymers Group, held in the University of London, April 15-17, 1958. The generally high level of the experimental work, the excellence of the reporting of it, and the inclusion of pertinent discussions are up to the high standards we have come to expect from British workers in the polymer field.

This book is by no means a manual of testing procedures and a compilation of data; it is a report of the scientific work being done on the methods of testing and the interpretation of the data in terms of molecular parameters. Viscoelasticity theory is brought to bear where applicable and several excellent examples of reduction principles applied to electrical and mechanical properties are given. Each chapter contains sufficient introductory material and references that the non-specialist can easily learn to follow the presentation.

This book is recommended for plastics engineers who wish to gain greater insight into the fundamental considerations of polymer physical properties.

Dr. E. H. Merz
Monsanto Chemical Co.

"HANDBOOK OF CHEMICAL MICROSCOPY, VOLUME I"

E. M. Chamot and C. W. Mason, John Wiley & Sons, Inc., 440 Fourth Ave., N. Y. 16, 1958, 502 pages (6" x 9"), $14.00

The reviewer has found that one of the best places to obtain a quick and clear picture of a new corner of a field of science is to consult a text or article on a technique used in the field. Usually enough theory is given to explain the applicability of the technique and in a manner that is much clearer than a theoretical article in the new field where much detail is devoted to proofs and exceptions. As a result new or revised texts on techniques are often more welcome on the engineer's bookshelf than are more complete texts devoted to a small corner of a field of science.

This is Chamot's well known "Microscopy" brought up to date with the able help of Dr. Mason who will undoubtedly have the responsibility of the next edition now that Dr. Chamot has passed away. The plastics engineer, especially if he is engaged in some research, will find much of interest in this reference aside from the above mentioned use. Although a variety of simple experiments are included, it does not have separate divisions for applications in the fields of biology, metallography, petrography, etc. The references are given as footnotes to the pages where they are most useful and in a few cases take up more than half the page, but are intended as recommended sources of additional information rather than forming a complete bibliography. Although the preface states that the text is not intended to be an encyclopedia, with the aid of a much expanded index it could serve as such as well as its intended use as a text to be read from cover to cover. For instance a special acknowledgment is made concerning the use of Bausch and Lomb's unusual color chart of birefringence on page 489, but the reviewer could find no reference on the chart or in the index to the way it could be put to use until a review of the book disclosed a brief reference to it under polarization.

The investigator in the field of plastics may be especially interested in the work on colloids, crystal structure and growth, particle size determination, and quantitative analysis of mixtures. The reviewer was surprised to find the frequency with which plastics and resins are used in work with the microscope, and the large amount of data given for plastics, resins, and fibers. For instance over half of the table of refractive indices on page 333 is devoted to macromolecular products from Acrylan through Teflon, etc., although Mylar film is not mentioned.

The reviewer was especially pleased with the sections on resolving power, interpretations of observed phenomena, phase contrast, techniques for sectioning tough plastics, replication with plastics, economical substitutes for expensive equipment, theory of biaxial crystals, crystal structure and handling, and size distribution of particles. Evidently Orr and DallaValle's new text on "Fine Particle Measurement" and the "zoom" binoculars are too recent to have been mentioned, but most of the techniques and theories seem to have been brought up to date enough to merit serious consideration of the text as an addition to the bookshelf of frequently consulted references.

Robert B. Bennett
Prof. of Chemical Engineering
University of Florida

HEAT SEALING AND HIGH-FREQUENCY WELDING OF PLASTICS

H. P. Zade, Interscience Publishing, Inc., 211 pages, $5.75

This book is a practical reference work in the specialized but very important field of sealing plastics films. Its purpose is to provide an up-to-date summary of information available in this rapidly advancing field.

The text of the book first gives brief property summaries of the thermoplastic resin which are best adapted to the two fabricating processes covered. The summaries appear to be generally reliable, although occasional errors were noted. Other brief chapters touch on the theories and techniques of heat sealing, high-frequency welding, and tool design for these processes. The remainder of the text, and the most important and extensive content of the book, is devoted to descriptions of commercial equipment available both here and abroad for the heat sealing and high-frequency welding processes. The remainder of the book, involving about one quarter of the whole, is devoted to an extensive forty page list of patents in this field, a trade name index, a glossary, and name and subject indices.

This book is a good concise summary of the present knowledge of this field, and it will be worthwhile to those interested in packaging or the large range of consumer applications which utilize these processes. The book was compiled by an authority on the subject, and was printed in Great Britain. It will be of special interest in this country as it gives extensive coverage to European practice as well as that of the United States.

Benjamin M. Walker
Resistoflex Corp.

PLASTIC SAFETY HANDBOOK

Produced by The Society of the Plastics Industry, Inc. in cooperation with the National Safety Council.

A Plastics Safety Handbook has been produced by The Society Industry, Inc. in cooperation with the National Safety Council. This Handbook is unique in that it is the first such publication devoted entirely to safety ever to be published for the plastics processing industry.

The Plastics Safety Handbook is the result of several years of voluntary work by specialists in the field of accident prevention. Every chapter has been written by volunteers experienced in each particular subject. The more than 200 pages of this Handbook cover extensively subjects applying particularly to the plastics industry such as Fire Prevention, Health and Hygiene, Inspection, Good Housekeeping, Machinery, Maintenance, Materials Handling.

Many processes in the plastics industry are specifically treated with the latest safety methods and practices explained in detail. Processes covered include calendering, coating, casting, compression and transfer molding, extruding, injection molding, laminating, mechanical finishing, reinforced plastics, thermal forming, tool and die making.

CAVITIES
make it a habit to hob it!
REINHOLD-GEIGER makes cavities . . . quickly and economically . . . in the largest Hobbing Department in the West. Whether you require one or one hundred cavities, there's a hobbing press at REINHOLD-GEIGER for your job. Precision cavities, identical in every respect, will increase your production at a minimum of expense.
REINHOLD-GEIGER's experience is available for proper hob design, steel, finish and heat treatment in the production of your hobbed cavities.
PRESSES: 5 Hobbing Presses — 100 to 4000 tons. Greatest number and range in the West.
STEEL: Largest and most complete stock.
PRODUCTION: Sawing, Blanchard grinding, annealing, and liquid honing under one roof.
DESIGNING
MOLDING
DIE MAKING
HOBBING
r g p
For additional information, write or phone
REINHOLD-GEIGER PLASTICS, INC.
8763 CROCKER STREET, LOS ANGELES 3, CALIFORNIA • PLeasant 2-7195

SPE RETEC Plastics in the Shoe Industry, sponsored last month by the St. Louis Section was a great success, with more than 350 in attendance. Picture at left shows RETEC Committee and attending National Officers. Left to right, first row, T. O. McNearney Section President, George W. Martin, National President-Elect for 1960, O. Wulfert RETEC Chairman, D. E. Eells, Councilman, T. A. Bissell, SPE Executive Secretary, C. D. Kacalieff. Back row, left to right, R. L. Reid, N. A. James, B. M. Coons, L. R. Dean, L. E. Lada, R. H. Koehrman, and H. L. Kalde.

News of S.P.E. Sections—in Pictures

Rain didn't stop members of the Kansas City Section from making a chartered plane trip to tour the new Western Electric plant at Omaha, Neb. Pictured, left to right, W. H. Peiler, D. C. Crawford, W. F. Condon, R. Thomson, K. C. Section President, H. D. Oliver, A. O. Hungerford, D. E. Eells, R. D. Bishop, G. T. Covert, W. Jensen, W. L. Short, E E. Epling, G. Milby, J. Westerfield, Miss M. Taylor, G. L. Stanley, J. J. Zahravik, R. Rounkle, F. Richards, C. R. Rounkle, F. C. Sutro, SPE National President, L. Bisbee, W. Spencer, L. Martin, and R. Burington.

Section News

Eastern New England Section

Section Elects New Officers

D. M. ROSATO

The September 22, 1959, SPE Meeting introduced the new officers of the Eastern New England Section. Mr. Gim P. Fong, President of the Section, presided. The new officers for the coming year are as follows:

Officers for 1959-60

President
Gim P. Fong, Raytheon Company

Vice President
Russell Ehlers, Lowell Technological Institute

Secretary
Alfred Simon, Raytheon Company

Treasurer
Howard Cookingham, D. H. Litter Company

This first meeting included a speaker on a relatively complicated subject which specifically provided interesting and educational items related to the Plastic industry. Mr. Nevis E. Cook, Chief of Boston District, Food and Drug Administration, discussed the Food additive Amendment and its effect on the Plastic Container manufacturer.

Philadelphia

Vinyl Stabilizers

GEORGE R. DEHOFF

October 27 was vinyl night for the Philadelphia Section and Chairman, J. P. Clancy of Emery Industries, Inc., had an excellent program prepared. Walter J. Smith of Firestone Plastics Company served as moderator for a panel discussion of vinyl stabilizers that thoroughly covered the subject from a review of their history through the effect of formulation variables and the influence on end-use and processing requirements to the use of epoxies as plasticizers and stabilizers. The panel speakers were Norman L. Perry of Argus Chemical Company, Harold Landfield of R. T. Vanderbilt Company, Theodore A. Girard of Nuodex Products Company, and R. F. Coyne of Rhom and Haas Company.

Before the vinyl program, Sid Levy reported on the activities of Philadelphia Section's Educational Committee. This group contains three subcommittees investigating the need for plastics courses in High Schools and Colleges and the need for (and review of) symposia meetings. This year the Philadelphia Section is sponsoring a series of evening courses (eight in all) at the Philadelphia Textile Institute. The Institute is seeking advice from SPE members on the level of education in Plastic Technology that is most needed.

Chicago

ABS Polymers

MARVIN S. LEVINE

The October meeting was highlighted by the presentation of a talk on "New Developments in ABS Polymers" by Howard H. Irvin, Vice President in charge of Research & Development of Marbon Chemical Co. The data presented aroused a great deal of interest and, judging by the reaction of the audience, showed that things to come are of prime interest and importance to an SPE group. Thanks to Mr. Irvin for a job well done.

Baltimore-Washington

Plastics at the Moscow Fair

STANLEY P. PROSEN

The October meeting held at the Hot Shoppe in College Park, Maryland, was called to order by Section President George Flanagan. The main topic of discussion was concerning the plans made for the RETEC to be held December 1, 1959.

The speaker of the evening was Dr. Albert G. H. Dietz, Professor of Mechanical Engineering at the Massachusetts Institute of Technology. The subject of his talk was his recent visit to Moscow in connection with the American Exhibit at the Moscow Fair.

Mr. Dietz was co-designer of the Plastic Parasol Pavillion which was one of the structures at the exposition.

The talk was illustrated with about 100 pictures taken in 3D. He discussed and showed the terrific effort in the development of better housing going on. It was interesting to see the beautiful churches which were all built prior to 1917 but are still maintained, in some cases at least, by the government. Other points of interest which he reported on was the Moscow University, a two-day visit to Leningrad, and, of course, the American Exposition. He reported that people were well dressed, friendly and talking peace. They were very much interested in American things. They are, however, enthusiastic about their country and feel that they belong to generation that is making new history.

Toledo

Toledo Section Makes Plant Visit, Had Plastics in Building as Topic

R. E. DUNHAM

The Toledo Section took advantage of the proximity of the Enrico Fermi Atomic Energy Power Plant construction at Monroe, Michigan and visited the installation, September 16th. This gigantic project was extremely interesting and provided a glimpse into the future progress in this vicinity.

At the Past President's Night, on October 21, the Toledo Section enjoyed "More Plastics–Better Buildings" presented by Earl Ziegler of Dow Chemical Co. The meeting was held at the Moongate Supper Club.

Mr. Ziegler presented many good applications for plastics in building and stressed the cost advantages which can occur along with the beauty and practical advantages of plastics over existing materials. It is estimated 414 million pounds of thermoplastics and 683 million pounds of thermosetting plastics are used in building now. Some applications mentioned of particular note are: inside partition covers, latex paints, insulation, flashing, shower floors, pipe lining, adhesives, vapor barriers, etc. The talk was highlighted by the colored slides used.

The Toledo Section voted to sponsor a $100.00 scholarship at the University of Toledo in the field of plastics or related field such as tool and die to be financed by voluntary contributions of the members.

It is with extreme sorrow that the announcement was made of the death from natural causes of E. O. Spaulding, who had been a member of the Toledo Section for many years.

North Texas Section

Plastics Engineers Hear Talk on Nylon and Teflon

DAVID A. DANIELS

At the October 19, 1959 meeting of the North Texas Section Society of Plastics Engineers, over 60 members heard Robert B. Koch, Technical Service Engineer for Polymer Corporation of Penn. discuss the physical properties of Nylon and Teflon. Also included in the presentation was the discussion of industrial applications. E. H. Swazey, Lone Star Plastics of Fort Worth, the first president of the newly-formed section, reported that 126 members had been gained during the first year of the section's activity. New committee chairman serving are: Membership; R. G. Myers, Rohm & Haas, Dallas; Program: Bill McCon-

nell, Air Accessories, Fort Worth; Education: Ray F. Uber, Phillips Chemical Co., Dallas: Finance: Clarence Garrard, Fort Worth National Bank, Fort Worth; Publicity: Joe M. Kern, Owens-Corning Fiberglas, Dallas; Attendance: J. A. Alexander, Alexander Plastics Co., Dallas; House: John Gillette, Fort Worth; RETEC: R. S. Perkins, Southwestern Plastic Pipe, Mineral Wells; and Credential; E. W. Hanszen, Hanszen Plastics, Dallas.

ATTENDING THE OCTOBER 19th meeting of the North Texas Section, Society of Plastics Engineers (left to right) are Ernest Dourlet, Cadillac Plastics, Dallas, Secretary; T. T. Tucker, Jr., Tommy Tucker Plastics, Dallas, President; Robert B. Koch, Polymer Corporation of Penn., guest speaker; and W. K. McConnell, Air Accessories, Fort Worth program chairman.

William M. Payne, Jr., Chief Engineer, Ordnance & Missile Division of Universal Moulded Products Corporation, Bristol, Va. will speak on structural applications of reinforced plastics at the November 16, 1959 meeting of the section. Outstanding in his field, he has been cited for contributions in rocket propulsion performance evaluation.

Rochester

Blow Molding

JOHN T. BENT

Mr. Lee J. Zukor, Engineering Editor of Plastics Technology Magazine, then presented a paper on "Blow Molding". A survey of different types of equipment currently available was presented both orally and in pamphlet form. The merits and disadvantages of each machine were discussed.

In addition to this most interesting presentation, Mr. Zukor had assembled an extremely interesting and informative collection of blow molded objects manufactured by the different processes. Slides and charts were aso presented to good effect.

After some time being spent in a question and answer period, the meeting was formally adjourned, followed by informal discussions. Seventy-three members attended.

Special note: At least 6 members of the Rochester Section attended the Trade Fair in Dusseldorf, Germany.

Upper Midwest Section

1959-1960 Program

FRANCIS W. BROWN

December 14—Balloons and their Operation—a film "Exploring the Edge of Space".

January 18—Zerlon 150, A. L. Bird, Dow Chemical Co. Epoxy Molding Compounds—New Fields for Molders, Paul E. Fina, Fiberite Corp.

February 15—Plastic Decoration and Vacuum Metallizing, Milton Z. Thorson, Red Spot Paint & Varnish Co., Inc.

March 21—New Extrusion Developments, Frank Nissel, Prodex Corp.

April 18—New Developments in Expandable Polystyrene, William J. Gort, Koppers Co., Inc.

May 16—Insulated Runner Systems for Molding Polyethylene, J. N. Scott, Phillips Chemical Co.

Guest speaker of the evening for the October meeting was Mr. J. R. Kent of Monsanto Chemical Company. Mr. Kent's talk, supplemented with slides, was on "The Effect of Structure of Thermoplastics on Physical Properties". The talk was primarily directed at the plastic fabricator and molder to show how they could better anticipate the behavior of plastic materials. It was pointed out by Mr. Kent that the molecular structure of thermoplastic materials is directly related to the various physical properties such as tensile strength, heat distortion point, rigidity etc. The talk was very interesting and well prepared.

Western New England

"Polypropylene—The Newest Commercial Member of the Polyolefin Family"

A. G. WINFIELD

With much interest focused on the polypropylene market potential, it was interesting to learn about the material from the representative of the company which has a 21-month head start in its commercial production in this country.

The very encouraging presentation was accompanied by slides and a multitude of molded articles. The material was presented on a lively and well-coordinated fashion in which a progress studies, market analyses and logical visualization of future potentials were considered.

With little reference to the Hercules proprietary polypropylene known as Pro-Fax, Mr. Bracken described the overall properties of the rigid material basically a structural plastic, with rigidity and surface hardness and which has high impact resistance, good fatigue characteristics, and is lightweight. It can be easily and brilliantly colored and has high heat resistance (up to 270 to 300F range). Its resiliency makes it suitable for almost indestructable hinges which have performed in excess of 250,000 flexes. The absence of cold flow allows force fit fabrication, and with good design, high assembly costs can be eliminated for such products as integrated eyeglass cases, lunch boxes, fishing tackle and tool boxes and record cases—to name but a few.

Miami Valley Section

Silicone Mold Releaser

STEPHEN D. MARCEY

The Miami Valley Section of the Society of Plastics Engineers, Inc. met for their second session of the 1959-60 season at the Wishing Well in Centerville, Ohio on Thursday, October 1, 1959. Speaker for the evening, following an excellent dinner, was Thomas N. Swan of G. E. Chemical & Metallurgical Division, Silicone Products Department, Cleveland, Ohio. His topic wao entitled "Silicone Releases and Elastomers", and was supplemented by slides. The talk encompassed a range of silicone mold releases and RTV elastomers with illustrated applications.

Connecticut Section

New Developments in Extrusion

K. G. CLARKE

"Latest Trends in Extrusion" was the topic of the regular monthly meeting of the Connecticut Chapter held on October 9 at the American Brass Company Country Club in Naugatuck, Connecticut. Mr. Robert Sackett of the Hartig Extruders Division of Midland Ross Corporation was the guest speaker and gave an excellent informal discussion on several recent developments in extrusion equipment.

Mr. Sackett discussed the advantages and disadvantages of valved extrusion, vented extrusion, high speed extrusion (high screw RPM), and induction heated extruders. The presentation was well reviewed as evidenced by the numerous questions which were asked by the group.

Milwaukee Section

Foam Magic

J. C. ENGMAN

Fifty members and guests were greeted at the October meeting by Herb Goeden, Section president. Foams were the topic of the evening. A film "Foam Magic for Home makers" was shown and Mr. Dan Shedd of Mobay Chemical presented a slide illustrated talk on reaction formula and process schematics of urethane foams.

Pioneer Valley

Finishing of Plastics

ROGER JOHNSTON

Finishing operations, such as degating, vacuum metallizing, and marking was the theme of the October meeting, presented by Sumner Raymond of Markhem Machine Co. and Howard Farrow, N.C.R. Equipment Corp. Some of the developments discussed: Gold covering on automobile glass, which will conduct electricity to defrost, plastic mirrors and vacuum metallizing the refractory materials with an electron beam. Pioneer Valley Section members note: Ladies night on December 10, 1959.

Newark

Newark Tours Union Carbide Plastics

DAVID SAHUD

The October meeting of the Newark Section consisted of a tour of the Union Carbide Plastics Company's extensive research and development facilities in Bound Brook, N. J. A brief talk on the history and objectives of the corporation and a film "The Petrified River" highlighted the tour. Subject of the film was the mining of uranium and industrial uses of radioisotopes. The meeting was attended by more than 400.

Ontario

Plastics in Buildings

H. A. SHURE

The October meeting was held in Toronto, Canada, with 78 persons attending. SPE tour speaker Earl E. Ziegler of the Dow Chemical Co. spoke on More Plastics–Better Buildings.

The course "Fundamentals and Technology of Plastics" sponsored by the Ontario Section commenced at the University of Toronto on October 6. There were over 210 students registered–a number which far surpassed expectations, but also indicating an extreme interest in plastics.

New York

Plasticizers and Vinyl Processing

CHARLES C. ORR

New York section's first meeting this year, held September 6th at the Governor Clinton Hotel, saw the Vinyl Professional Activities Committee start the season with a two-part forum on "The Effect of Plasticizers in Processing Vinyls."

Roy L. Kern, Thompson Chemical Co. moderated the program. Speakers were Walter F. Waychoff, Monsanto Chemical Co. and Russell A. Park, Firestone Plastics Co.

Jud Decker and Gerry Gilmore, both of Bopp-Decker Plastics described "Practical Considerations in the use of Sequential Impact Molding."

Vacuum Formers Sub-Group commenced the season with a series of round table discussions which will survey the specific problems of their industry. Some items to be considered: Materials; Molding techniques; Equipment; Cost Analysis; Molds; Ethical Practices and Procedures; and Forming a Set of Standards.

New York's Reinforced Plastics Professional Activities Committee met September 23rd at Patricia Murphy's Candlelight Restaurant, Manhassett, L. I. George Lubin of Grumman Aircraft recounted his experiences during his trip to Russia and visit to the American Exhibition.

New York Section Sets Up Courses in Plastics

The New York Section of the Society of Plastics Engineers has instituted three courses in plastics to be held at the New York Institute of Technology, New York, N. Y. Each will be a 14-week course. The three courses are as follows: Extrusion, to be held on Mondays, under the direction of Leo Gans of Anchor Plastics; Injection Molding, on Tuesdays, under the direction of Irving Rubin, Robinson Plastics; and Process Properties of Plastics, on Thursdays, under the direction of Dr. Alex Sacher of Standard Insulation. Classes will run from 7 to 9 in the evening. The session began on October 19. The fee for the course is $35 plus $5 for registration. The educational committee of S.P.E. that set up the course was under the direction of Ralph Biondi of W. R. Grace & Co., and Herb Weber of Rotuba Extruders, Inc.

St. Louis

St. Louis Discusses Polypropylene

LYLE R. DEAN

The October meeting of the St. Louis Section was held at the Prime Rib on Clayton Road, October 19, 1959. Twenty-six members and guests were present.

Otto Wulfert, Chairman on the RETEC "Plastics in The Shoe Industry," reported that this RETEC has been well advertised in the SPE Journal and throughout the shoe industry. Since the writing of this report, the RETEC was held and was a great success.

The speakers of the evening were Ken Jones and Bill Claypoole of Spencer Chemical Company, Kansas City, Missouri. They gave a good presentation on the markets that Spencer sees for their new product polypropylene.

Kentuckiana

Foams in Production

R. O. CARHART

The October meeting of the Kentuckiana Section, SPE, was held at Bill Boland's Dining Room on October 21, 1959, with a very gratifying 47 members and guests in attendance.

Following dinner, Mr. D. P. Shedd of Mobay Chemical Company discussed "Polyurethanes". His talk was well illustrated with slides and covered the chemistry of foams, methods for producing them, data indicating their growth potential and some actual production set-ups for their production. Also shown was a short movie covering the applications of polyurethane foams in the furniture field.

Golden Gate

Polyethylene in Injection Molding

THEO. V. MALIANNI

The October meeting was held at the International Inn in South San Francisco with 54 members and guests in attendance. Mr. Len Faber, Program Chairman introduced Mr. O. G. Maxson, speaker for the evening. Mr. Maxson is the Plastics Technical Service Representative for Dow Chemical Co., in Torrence, California and proved he was well qualified to speak on mold design and technology of Polyethylene. He stressed the adaptability of polyethylene to molding, particularly in injection molding which accounts for about 18% in the U. S. today. Aided by slides, he explained the importance of the relation of the size of sprues and runners to

the size of the machine and weight of the shot. Since polyethylene is a soft plastic, other slides showed that the full round runner is more desirable than the half-round or trapazoidal. The size and shape of the gate was shown to be very important to the thicknesses of the sections.

Continuing on molds, he explained that parts warp very much in proportion to mold temperatures, the warmer the mold, the more the shrinkage. Faster cycles however, can be obtained with cold molds and some molders even employ the use of refrigerated water. Since polyethylene is soft and easy to mold, it is also susceptible to jetting, causing skin imperfections.

Binghamton

Latest Developments in Vacuum Forming

L. J. PRANITIS

At the new Sheraton Inn, on October 22nd., Mr. William A. Kelley of Monsanto Chemical Co. addressed 39 members and guests of the local SPE section. His topic, "Latest Developments in Thermoforming Mass Production Techniques", proved to be extremely interesting and the presentation was supplemented with slides and movies.

Mr. Kelley has been working in Monsanto's Technical Service Department in Springfield, Mass. for the past three years, specializing in the extrusion and vacuum forming of high-impact styrene. His intelligent delivery and detailed explanations certainly indicated a very thorough knowledge of this subject.

New SPE Tour Speaker on Polypropylene

Wm. R. Claypoole, Spencer Chemical Co., has been added to SPE's growing list of tour speakers. Mr. Claypoole and members of his staff are available to talk on "Applications of Polypropylene" and prepared to gear this subject to whatever field your particular Section finds of interest. Section presidents and program chairmen contact John A. Pickard, Chairman, Speakers Sub-committee, The Dow Chemical Co., Midland, Mich.

W. R. Claypoole

SPE Members Attend Dusseldorf Plastics Fair

Three members of the New York Section get together at Dusseldorf. From left, Herb Proskie, Herb Weber, President of the New York Section, and George Ventz.

Bill Willert, Newark Section, takes in the exhibits.

16th ANTEC

ANNUAL TECHNICAL CONFERENCE—January 12-15, 1960, The Conrad Hilton, Chicago, Ill. Sponsored by the Chicago Section. For more information, wire or phone General Chairman Franklin L. Fine, Rohm & Haas Co., 5750 W. Jarvis Ave., Chicago 31, Ill.

17th ANTEC

ANNUAL TECHNICAL CONFERENCE—January 24-27, 1961, at the Shoreham and Park-Sheraton Hotels, Washington, D. C. The 17th ANTEC is sponsored by the Baltimore-Washington Section. For more information contact General Chairman Dr. Gordon Kline, National Bureau of Standards, Washington, D. C.

1960 RETECS

PLASTICS IN PETROLEUM AND PETROCHEMICAL INDUSTRIES—April 20, North Texas

VINYL PLASTICS—June, Eastern New England

PLASTICS IN BUSINESS MACHINERY—September, 22, 1960, Binghamton

TOOLING FOR THE PLASTICS INDUSTRY—October 19, New York

BLOW MOLDING—November, Newark

Offers of papers in the technical area of each Regional Technical Conference are solicited by each sponsoring Section. Please submit offers and abstracts to Section President indicated below for each RETEC.

Presidents of sponsoring sections are:

North Texas
E. H. Swazey, Lone Star Plastics, P.O. Box 9817, Fort Worth, Tex.

Eastern New England
Gim P. Fong, 9 Maple St., Auburndale, Mass.

Binghamton
Leroy N. Chellis, International Business Machines Corp., Endicott, N. Y.

New York
Herb Weber, Rotuba Extruders Inc., 437 88th St., Brooklyn 9, N. Y.

Newark
Allan G. Serle, 2586 Juliat Place, Union, N. J.

Technical Meetings Calendar

High Speed Testing Symposium

The Second Annual Symposium on High Speed Testing sponsored by our company will be held at the Somerset Hotel, Boston, Massachusetts on January 27, 1960.

This is the second in a series of symposia designed to provide a medium for a genuine interchange of information on high speed test techniques, interpretation of data and the significance in application of results.

Plastics Around the World

This month's column has been made possible through the contributions of these abstracters:

Alfred L. Alk (Materie Plastiche)
Philip G. Fleming (Mechanical Engineering)
Leonard S. Buchoff (Materials in Design Engineering)
James Margolis (Der Plastverarbeiter)

Italy

MATERIE PLASTICHE

SEPTEMBER 1959

The Co-Polymers of Maleic Anhydride—Hydrosoluble Resins—E. Ferraris

Part 2—Continuing the review from last issue. This section covers copolymers of maleic anhydride with vinyl acetate, alkyl vinyl ether, acrylic derivatives, and olefins and a brief discussion of other copolymers. The bibliography includes reference number 223.

SEPTEMBER 1959

Spherulitic Structures of Some Isotactic Polymers—G. Putti, E. Sabbioni

The physical characteristics of a polymer are altered drastically if the polymer can be crystallized. Isotactic polypropylene, polybutylene and polystyrene have been studied with the polarizing and electron microscopes; their crystallization into spherulites has been carefully observed and are described and illustrated here.

U.S.A.

MECHANICAL ENGINEERING

OCTOBER 1959

Plastics (pp 51-53)—Irving Gruntfest

It is now accepted that reinforced plastics are useful in certain types of ultrahigh—temperature service. However, it is pointed out that useful hand-book-type data is not available for general Engineering use.

This article compares plastics to other materials, all tested under a variety of high-temperature environmental conditions. Graphs, tables and discussions are used. The behavior of plastics is also discussed, and plastic versus plastics comparisons are noted. Selection and reinforcement data are given.

It is noted that "the art of application of plastics in high-temperature service is so young that design work in this area is still quite difficult. What is clear however, is that for short-time applications some plastics must be considered. Furthermore, at the highest temperatures, at which no materials are stable, Plastics may be the most durable substances available."

Ed's Note: This article was originally condensed from Paper No. 59-MD-1, Aerosciences Laboratory, Missile and Space Vehicle Department General Electric Co., Phila., Pa. (I Gruntfest)

I would recommend the original article for S.P.E. Consumption

MATERIALS IN DESIGN ENGINEERING

SEPTEMBER 1959

New Ways to Combat Corrosion—R. J. Fabian

Glass polyester laminates are being used in petroleum and chemical equipment requiring resistance to chemicals and weathering. Chlorinated polyether parts and coatings provide high resistance to water chemicals and abrasions in valves, water meters and other parts. Plastic pipe is used because of its excellent resistance to salt water and other corrosives. Epoxy resin structures provide high mechanical strength and resistance to special chemicals. Organic coatings can now be applied in the field in heavy thicknesses with fewer coats.

Germany

DER PLASTVERARBEITER

AUGUST, 1959

New Developments in Vacuum Forming—Alfred Riemenschneider

German progress in vacuum forming has been with soft PVC especially. By employing high-frequency welding for a very short time period, upholstered furniture and furniture linings are produced from this material. What is significant is that linings can be made with much higher production capacity through vacuum forming. In addition, a supporting film (which is expensive) can be eliminated. Vacuum forming of soft PVC film can be used for making various interior furnishings for automobiles.

Recently acrylics have begun to be vacuum formed. Acrylics have finally been made in extrudable grade, and the first sheets of this material have appeared on the market.

Main attractions of vacuum forming include: the precision-forming of articles, and improvement of automatic production.

AUGUST, 1959

Comparison: Paris and London—A. R.

Two similar conferences were held recently: in Paris, from June 18 to 29, at the Salon Internationale de la Chimie, and in London, from June 17 to 27, at the International Plastics Exhibition.

At Paris there were 350,000 visitors and 16,500 products displayed. As in London, this was more a national than an international exhibit. Some of the highlights in Paris included the BANDERA extruder TR120, BIPEL's heavy presses, CONVERT's semifinished vacuum-formed products, polyester sheets and pigment and lacquer raw materials, GANT-PVC used in protective garments, GASCHOT's "Teflon" and "Gaflon," C. IVROUD's extruder, and ORGANICO showed its polyamid "Rilsan." REICHHOLD BECKACITE S. A. displayed about forty of its known resins.

In London, the international exhibit drew about 106,000 people. Not only in quantity and variety, but to some extent in quality, too, the London exhibit exceeded the one in Paris. Particularly notable were the large polyester products (for example, a swimming pool 10 x 5 meters).

First National Technical Conference a Success

Past presidents of the Southern California Section of SPE are, left to right, seated: Donald A. Hamilton, Jack G. Fuller, Jr., Thomas Schaub (present president), William Dewar. Standing, left to right: Brandt Goldsworthy, Elbert Davis, Willard G. Lundberg, C. C. Booth, and John Delmonte. Not shown in photo are Austin Herbst and Walter Kadlec. Past presidents are holding certificates of recognition presented to them at one of NATEC luncheons by Frederic M. Rea, publisher of WESTERN PLASTICS.

Luncheon Speakers at NATEC ► Dr. L. Larmore W. Zisch

Correction

Vacuum Feed Extrusion

BY

WALT M. MUNDY, NATIONAL RUBBER MACHINERY CO., PLASTICS EQUIPMENT DIV. AKRON, OHIO

The photographs appearing on page 888 of the October SPE Journal were inadvertently matched with the wrong Case Histories. Both photographs appearing on page 888 should be associated with Case History 3.

Plan to attend the 16th ANTEC

see page 1027

FOREMOST new H.D. series!

This new line of heavy-duty grinders has received tremendous acceptance quickly, due to its rugged construction and ease in cleaning. They are currently available from stock in the following models:

Model	HP	No. of Rotor Blades	Throat Opening
HD-1	3	2	8½" x 10"
HD-1A	5	4	8½" x 10"
HD-2	5	2	10" x 14"
HD-2A	7½	4	10" x 14"

The 4-bladed rotor machines should be used for heavier duty applications, such as small purgings, pipe fittings, and nylon gears. Manufactured by Foremost Machine Builders, Inc., Livingston, New Jersey, and sold by:

The Rainville Company
657 Franklin Avenue, Garden City, L. I., N. Y.

DISTRICT OFFICES: Quinebaug, Connecticut; Abington, Pennsylvania; Franklin, Pennsylvania; Detroit, Michigan; Dayton, Ohio; Evansville, Indiana; St. Louis, Missouri; Chicago, Illinois; Minneapolis, Minnesota; Dallas, Texas; Alhambra, California; Toronto, Canada (Rusky Manufacturing & Tool Works, Limited).

Index - SPE Journal - Volume 15 1959

Title and Author

Aluminum Foamed Plastic Panels—L. W. Hovland and E. R. McLaughlin, December, p. 1066

An Easy Way to Control Polyester Resin Cure—J. M. Smith and Robert B. Bennett, October, p. 858

Castable Conductive Plastics—William C. Turner, March, p. 216

Chain Rupture by Shear in Molten Polymer—Herbert A. Pohl and J. Kenneth Lund, May, p. 390

Chemistry and Performance of Cyanoacrylate Adhesives—H. W. Coover, Jr., J. B. Joyner, N. H. Shearer, Jr., and T. H. Wicker, Jr., May, p. 413

Comparison of Time Dependent Mechanical Properties of Plastics—Bryce Maxwell, June, p. 480

Continuous Peel Strength of Copper Clad Laminates—C. S. Kepple, December, p. 1070

Creep Behavior of Transparent Plastic at Elevated Temperatures—F. L. McCracken and C. Bersch, September, p. 791.

Crystallization Kinetics in Polymeric Systems—L. Mandelkern, January, p. 63

Definition of a Moldmaker—E. J. Czaszar, September, p. 812

Degradation of Cellulose Acetate Films—William K. Wilson and D. W. Forshee, February, p. 146

Designing Rigid Urethane Foams for Low Moisture Permeability—C. Minor Barringer, November, p. 961

Determination of Moisture in Nylon Molding Powder—L. Paggi, December, p. 1083

Diepoxides With Improved Properties—Donald R. Beasley, April, p. 289

Dynamic Mechanical Properties of Epoxy Resins—D. H. Kaelble, December, p. 1071

Effect of Wear on the Delivery Capacity of Extruder Screws—B. H. Maddock, May, p. 433

Effective Use of High Temperature Resistant Polyester Resins—James P. Walton, July, p. 567

Effects of Tertiary Amine Catalysts on Some Foam Properties—G. T. Gmitter, E. E. Gruber and R. D. Joseph, November, p. 957

Engineering Molded Parts for Business Machines—Byron W. Nelson, February, p. 131

Epoxy Novolacs—D. D. Applegath, R. F. Helmreigh and G. A. Sweeney, January, p. 39

Extruders and the Packaging Industry—Albert A. Kaufman, January, p. 54

Extrusion Bibliography—L. F. Street, July, p. 561

Extrusion of Linear Polyethylene Film—Robert Doyle, December, p. 1079

Extrusion of Polyethylene Film With Controlled Properties—W. A. Haine and H. B. Robinson, March, p. 233

Extrusion of Polypropylene—Russell D. Hanna, June, p. 499

Fabricating Silicone Laminates to Get the Most Strength—W. W. Breed, H. Christie, C. Bolze and F. Baiocchi, March, p. 220

Faster Cure Through Hotter Electronic Preheat—A. J. Guzzetti and R. L. Wechsler, April, p. 293

Flammability Evaluations in Safety Codes—Mathew M. Braidech, January, p. 35

Formulating a Castable Polyurethane—A. J. Quant, April, p. 298

Future of Engineered Molecular Studies—Giulio Natta, April, p. 292

Going Into Fluidized Bed Coating—Joseph Gaynor, December, p. 1059

Ground Radomes—S. C. Nilo, February, p. 157

High Density Polyethylene Protective and Functional Coatings—S. E. Hmiel and H. C. Guy, July, p. 540

How To Modify Your Injection Molding Machine for Better Molding Cycles—Milton Sanders, November, p. 989

How to Reduce Carbonization in the Injection Cylinder—C. S. Imig, February, p. 142

Improved Instrumentation for Screw Extruders—E. C. Bernhardt, August, p. 735

Induction Heating for Injection Molding Machines—W. J. Goodwin, March, p. 241

Infrared Spectra and the Structure of High Polymers—S. Krimm, September, p. 797

Infrared Spectrophotometric Studies of Plastics—Raymond Sawyer, July, p. 537

Insulated Runner Systems for Injection Molding—J. L. Scott, D. L. Peters and B. J. Boeke, September, p. 785

Interfacial Polycondensation - Versatile Method of Polymer Preparation—P. W. Morgan, June, p. 485

Interfacial Properties of Polyesters at Glass and Water Surfaces—Robert R. Stromberg, Wendell M. Lee and Alan R. Quasius, October, p. 883

Low Pressure Injection Molding—Gordon Cooper, November, p. 966

Materials for Long Range Missiles and Space Vehicles—William A. Mrazek, March, p. 211

Mold-Filling Rates, Better Parts With Proper—Gordon B. Lankton, January, p. 31

Molds for Blow Molding—George E. Pickering, October, p. 891

New Method for Determining the Second Order Transition in Thermosetting Polymers—R. W. Warfield, August, p. 625.

Notch Sensitivity of Reinforced Plastics—E. L. Strauss, October, p. 894

Nuclear Resonance Studies of Polymer Chain Flexibility—W. P. Slichter, April p. 303

Pinpoint Important Process Variable with Polyvariable Experimentation—F. E. Satterthwaite and D. Shainin, March, p. 225

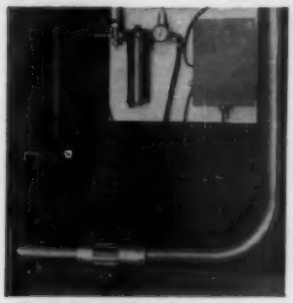
Pitfalls in Evaluation of PVC Stabilizers—Charles H. Fuchsman, March, p. 214

Plastics as Iodine Vapor Barriers—Samuel D. Toner, January, p. 48

Plastic Foams—C. R. Davall, November, p. 954

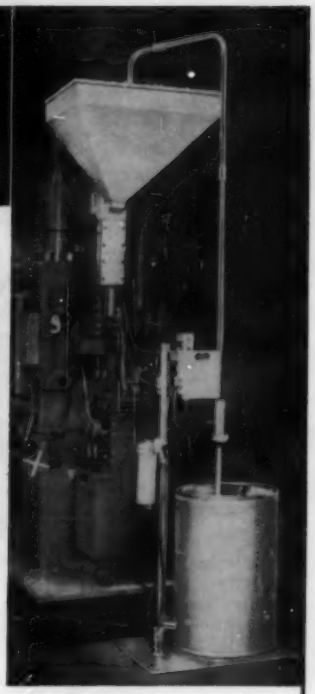
Whitlock The Complete Line of
CONVEYORS • DRYERS • SPECIAL EQUIPMENT
for handling all plastic materials!

Automatic Dryers
Dehumidifies drying air to a minus 20 dew point in a closed system - preheats material - capacities to 600 lbs. per hour.



Bulk Handling Conveyors
Automatic or manual - capacities to 2,500 lbs. per hour.

Filter Cone Attachment
Automatic - eliminates dust caused when transferring plastic materials.



Self Supporting Conveyors
Automatic or manual - capacities to 1,200 lbs. per hour.

The Whitlock line gives you both standard and custom built equipment. *Write for complete catalog.*

WHITLOCK ASSOCIATES INC.
21655 Coolidge Hwy., Dept. S. Oak Park 37, Mich.

INDEX—Continued

Plastics as Construction Materials in the Steel Industry—Joseph Bigos, November, p. 978
Plastics in the New Age of Discovery—W. E. Zisch, December, p. 1042
Plastics in the Auto Industry—R. H. Dean, R. E. Burk, T. W. Mullen, R. L. Gardner, D. A. Hurst, and J. F. Woodman, November, p. 968
Plastics Radomes at Elevated Temperatures. Theory and Practice—Fred H. Behrens and Cecil W. Gwinn, October, p. 881
Plastics Research in Poland—Jerome Formo, October, p. 858
Principles of Rotary Molding—John C. Reib, July, p. 546
Producing Special Properties in Plastics with Fillers—Jerome Formo and Robert Isleifson, August, p. 627
Progress in Five Years of Research in Stereospecific Polymerization—Giulio Natta, May, p. 373
Progress in Urethanes—M. E. Bailey, April, p. 285
Properties of Foams and Laminates Under Shock Loading—R. H. Supnik and M. Silberberg, January p. 43
Quick Test for Carbon Black Dispersion—W. G. Best and H. F. Tomfohrde, III, February, p. 139
Refractive Index Method for Determining Cure Rates of Epoxy Resins—H. Dannenberg, October, p. 875
Reinforced Plastics for Rocket Motor Applications—George Epstein and J. C. Wilson, June, p. 473
Relationship of Physical Properties to Structure in Linear Polymers of Ethylene and Propylene—L. T. Muus, N. G. McCrum and F. C. McGrew, May, p. 368
Review of Stress-Cracking in Polyethylene—John B. Howard, May, p. 397
Saturable Core Reactor Temperature Controls—George Northrop, February, p. 137
Scale-Up Theory, Extruders—B. H. Maddock, November, p. 983
Short-Time Vs. Long-Time Properties of Plastic Pipe Under Hydrostatic Pressure - A Comparison—Leonard F. Sansome, Jr., May, p. 418
Some New Verifications of Power and Heat Theory in PVC Extrusion—Frank C. Schutz, April, p. 311
Special Considerations in Injection Molding Design—E. J. Csaszar, November, p. 987
Specific Heat of High Polymers—R. W. Warfield, M. C. Petree and P. Donovan, December, p. 1055
Stabilization of Mixtures Containing PVC—Charles H. Fuchsman, August, p. 787
Stabilization of PVC Towards Sunlight—Norman L. Perry, July, p. 550
Thermal Incline as an Evaluation Tool in Fluidized Bed Coating—C. J. Metz, December, p.
Unique Modifier for Epoxy Resins—H. D. Barnstorff, H. D. Cummings, J. A. Cannon and A. Y. Coran, October, p. 873
Use of Flexible Conduits in Extrusion—E. C. Bernhardt, September, p. 807
Use of Reground Glass-Filled Polystyrene—George R. Rugger, December, p. 1053
Use of Thermoset Laminated Plastics in Electronic Applications—Paul V. Brown, November, p. 974
Vacuum Feed Extrusion—Walt M. Mundy, October, p. 887
VHF Preheating for Thermosetting Molding—J. F. Trembley, July, p. 543
Visual Analysis of Flow and Mixing in Extruder Screws—B. H. Maddock, May, p. 383
Warpage in Center-Gated Articles—L. Paggi, September, p. 810

Employment & Service Guide

POSITIONS OPEN

TECHNICAL SERVICE ENGINEERS

Plastic Materials

Technical College graduate with degree in chemistry or chemical engineering with at least three years experience in the application of thermoplastic materials in the molding industry. Mold design experience is desirable.

Work will be in the new and exciting polycarbonate resin field. Headquarters are in Pittsfield, Mass. Some travel is required.

Please give full details of education and experience in your reply and state your salary requirements.

Technical Personnel Office

CHEMICAL MATERIALS DEPT.

GENERAL ELECTRIC

1 PLASTICS AVE. PITTSFIELD, MASS.

West Coast Sales Engineer
for Leading Mold Base Mfr.

Qualified man to represent orginator of Standard Mold Bases in established West Coast territory. Will operate through company's fastest growing branch office and warehouse located in Los Angeles. To sell the most complete line of Standard Mold Bases and moldmakers' supplies to established accounts in the plastic molding and die casting industries.

Good salary and commision. Car and hospital-medical benefits furnished by company.

Excellent opportunity for the right man to grow with the West Coast. Should have engineering education and experience in plastic molding and die casting.

Prefer man with proven ability in the West Coast area. Send resume with photograph to:

Detroit Mold Engineering Co.
6686 E. McNichols Road
Detroit 12, Michigan
Attn: Mr. L. J. Morrison

TECHNICAL SUPERVISOR
Plastic Coating Operation

Texon, Inc., producer of impregnated fiber products, has an opening for a technically trained man as Technical Supervisor and Assistant to the Plant Manager of the Coated Products Division located in Holyoke, Mass. Applicant should have several years experience in the field of treated papers and/or plastic coating. This is a challenging responsible position for an aggressive man in a growing company. Company benefits include medical coverage, life insurance and retirement program.

Send detailed resume in confidence to:

Wesley N. Stickel, Vice President
Texon, Incorporated
South Hadley Falls, Massachusetts

DESIGN ENGINEER

Aggressive, responsible engineer who can get things done quickly and accurately. Degree or equivalent with machinery design experience and preferably some knowledge of extrusion.

Write describing experience, education and salary requirements to A. W. Pamper, Director of Engineering

WALDRON-HARTIG

Division of Midland Ross Corp.

P. O. Box 791, New Brunswick, N. J.

Design Engineer for Plastic Extruders
and accessory equipment

Graduate Engineer preferred with design experience and practical knowledge of plastic extrusion field. Must be capable of assuming responsibility for design and development of machinery in this field. Excellent opportunity for permanent position with rapidly expanding company. Please send full information on experience, education and salary requirements.

Modern Plastic Machinery Corporation
64 Lakeview Avenue
Clifton, N. J.

SALES ENGINEER—PLASTICS

Chemical Division has opening for man with Chemical Engineering or Chemical degree who has experience in vinyl compounding.

Headquarters in Akron. Work with customer, field sales, and company technical personnel.

Excellent employee benefits.

Write, giving information regarding experience and education.

W. J. McLarty
The Goodyear Tire & Rubber Co.
1144 E. Market Street
Akron 16, Ohio

CHEMISTS AND ENGINEERS

PLASTICS

CHEMISTRY AND ENGINEERING

You are invited to investigate important positions now open at IBM's modern facilities at Kingston, New York. You will have an opportunity to make important contributions in new uses of plastics for advanced electronic systems.

COMPONENT PLASTICS CHEMIST:

This position involves a specialized assignment in advanced product engineering. You should have a thorough knowledge of plastics with emphasis on encapsulating materials. Your principal work will be the development of new compounds, having characteristics not now available, to meet the requirements of the unique applications for which they will be used. The scope of this assignment calls for an individual with an advanced degree or equivalent experience, plus several years of background in plastics materials.

PLASTICS PRODUCTION ENGINEER:

This opening calls for an advisor in advanced electronics product design. You must have a detailed knowledge of production techniques for plastics and be capable of supervising mold design. You will select the material to be used and the production methods required. This assignment requires both a technical education in this field and several years of practical experience.

Please write, outlining your qualifications and experience, to:

Mr. R. B. Elting, Dept. 666L
IBM Corporation
Kingston, New York

IBM®

INTERNATIONAL BUSINESS MACHINES CORPORATION

POSITIONS OPEN

OPPORTUNITY IN TECHNICAL SALES
with
MOBAY CHEMICAL COMPANY
in Pittsburgh

Would you like to step into an important, recently-created position with a research-and sales-minded young company preparing to introduce a new type of industrial plastic for major design-engineering and original equipment markets? Opportunity for further technical study and combined technical service and sales training with direct industry contact at decision-making levels.

A number of such openings are immediately available. Company: Mobay, a jointly-owned associate company of Monsanto and Farbenfabriken Bayer A. G., of West Germany. Product: Polycarbonate thermoplastic resins. Assignments: Field technical service and market development. Location: Pittsburgh.

Qualifications: B.S., M.S. in Chemistry or Chemical Engineering, plus some thermoplastics experience in research or technical service. Mobay is first in urethane chemistry and will be the first commercial producer of polycarbonate resins in the United States.

MOBAY CHEMICAL COMPANY
Director of Personnel
Dept. SP Pittsburgh 34, Pa.

Mobay manufacturers isocyanates, polycarbonates and urethane chemicals for foams, elastomers and coatings.

MOBAY
First in Urethane Chemistry

SITUATIONS WANTED

CHEMICAL ENGINEER

D.ChE with over 20 years experience in thermoplastic film, sheet and molding material research, development, control, supervision and management. Excellent knowledge of materials, production methods, processing equipment and applications. Strong organic background. Publications, patents and teaching experience. Desires challenging position in product development or research and development. Minimum salary $15,000. Reply Box 6759, SPE Journal, 65 Prospect St., Stamford, Conn.

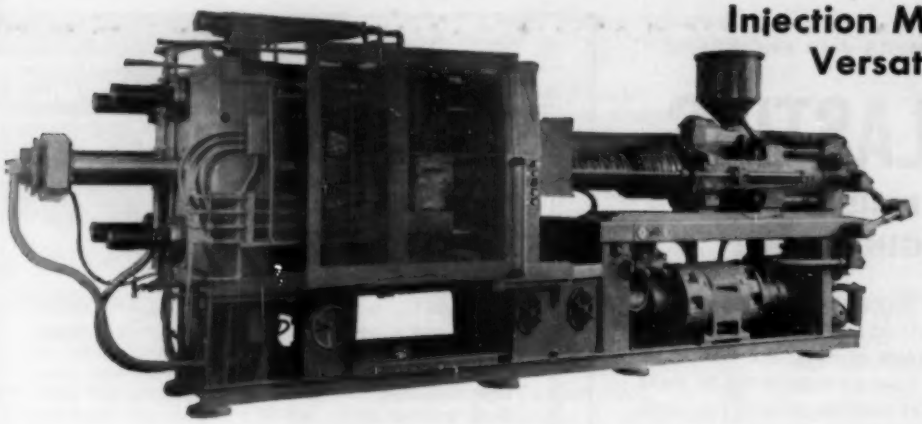
CLASSIFIED RATES

"Position Open" and "Position Wanted"—Minimum charge: $7.00; per word. $0.25. SPE members in good standing are entitled to a total of three no-charge "Position Wanted" advertisements during any twelve month period.

"Machinery, Equipment, Materials and Services"—Minimum charge: $15.00; per word: $0.50.

All ads include one bold face caption line. Additional caption lines at $2.00 extra per line. Boxed ads (four side rules) $2.60 additional charge.

Last day for inserting ads is the first of the month preceding date of publication.



Injection Molding's Most Versatile Performer!

IMPCO

Announcing **the new 20 ounce Impco**

Model HA16–425 **720 Dry Cycles Per Hour**

200 Pounds Per Hour Plasticizing Capacity

24½ Inch Stroke **Hydraulic Knockout**

IMPROVED MACHINERY INC. NASHUA, NEW HAMPSHIRE

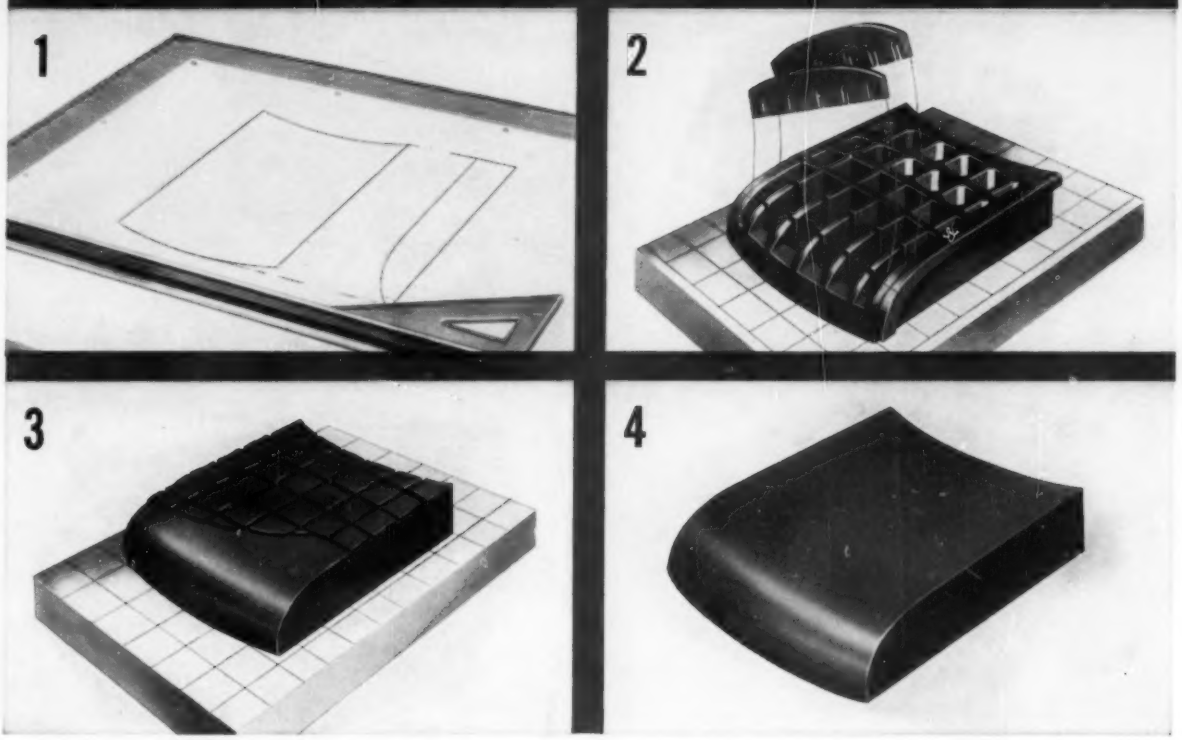
In Canada, Sherbrooke Machineries Ltd., Sherbrooke, Quebec

Export Distributors: Omni Products Corp., 460 Fourth Avenue, New York, New York

Advertisers' Index

Allied Chemical Corp., National Aniline Div. 1102
American Cyanamid Co., Plastics & Resins Div. .. 1051
Argus Chemical Corp. 1052
AviSun Corp. 1017, 1018, 1019, 1020
Bee Chemical Co., Logo Div. 1050
Continental Carbon Co., Div. Witco Chemical Co. 1036
Detroit Mold Engineering Co. 1028
Dow Chemical Co. 1034, 1035
E. I. du Pont de Nemours & Co., Polychemicals Div. 1049
Enjay Co., Inc.—Chemicals 1026
Gering Plastics, Div. of Studebaker-Packard Corp. 1021
B. F. Goodrich Co. 1044
Hartig Extruders, Div. of Midland-Ross Corp. 1040
The Hydraulic Press Manufacturing Co. 1033
Improved Machinery, Inc. 1100
Injection Molders Supply Co. 1082
Kingsbacher-Murphy Co. 1087
Logo Div., Bee Chemical Co. 1050
Metal & Thermit Corp. 1043
Midland-Ross Corp., Hartig Extruders Div. 1040
Monsanto Chemical Co.—Organic—Plasticizers 1041
National Aniline Div., Allied Chemical Corp. 1102
National Distillers & Chemical Corp., U. S. Industrial Chemicals Co. Div. 1031, 1032
Naugatuck Chemicals Div., U. S. Rubber Co. 1038, 1039
Package Machinery Co.—Reed-Prentice Sales Div. 1030
Charles Pfizer & Co., Inc.—Industrials 1037
Phillips Chemical Co. 1029
Plastics Engineering Co. 1045
Polychemicals Div., E. I. du Pont de Nemours & Co. 1049
Prodex Corp. 1078
Rainville Co. 1095
Reed-Prentice Sales Div., Package Machinery Co. 1030
Reichhold Chemicals, Inc. 1101
Reinhold-Geiger Plastics, Inc. 1089
Shell Chemical Corp. 1016
Spencer Chemical Co. 1024, 1025
Studebaker-Packard Corp., Gering Plastics Div. 1021
Union Carbide Plastics Co., Div. of Union Carbide Corp. 1046, 1047
U. S. Industrial Chemicals Co., Div. of National Distillers & Chemical Corp. 1031, 1032
U. S. Rubber Co., Naugatuck Chemicals Div. 1038, 1039
Whitlock Associates, Inc. 1097
Witco Chemicals Co., Continental Carbon Co. 1036

NOW! A FAST, ECONOMICAL METHOD FOR MAKING MASTER MODELS



. . . developed by Kish Industries using

RCI EPOXY RESINS

• Master models are made faster and better using this new Kish process* made possible by a completely different type of epoxy formulation – based on RCI EPOTUF epoxy resins.

Here, briefly, is how the Kish system works:

(1) Starting with the draft or styling print, templates are cut from pre-cast KiPlaBoard (fully-cured epoxy board made in varying thicknesses).

(2) These templates are bonded into an "egg crate" having the general shape of the model.

(3) The open areas of the "egg crate" are filled with Kish No. 44 Resin Compound (formulated with RCI EPOTUFS) and after the compound cures the rough model is shaped and finish-surfaced using standard woodworking techniques.

(4) The finished model is grain-free, dimensionally stable, and unaffected by moisture and weather. It will not chip or deteriorate with age and can be altered simply by bonding additional Epotuf-based material on the model.

This remarkable Kish innovation is just one of a constantly growing number of jobs done more efficiently and economically with versatile RCI EPOTUF epoxy resins.

**Complete information on the Kish System is available from Kish Industries, Inc., 1301 Turner Street, Lansing 6, Michigan.*

Creative Chemistry
...Your Partner in Progress

RCI

REICHHOLD

REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N.Y.

Synthetic Resins • Chemical Colors • Industrial Adhesives • Phenol • Hydrochloric Acid • Formaldehyde • Glycerine • Phthalic Anhydride • Maleic Anhydride
Sebacic Acid • Ortho-Phenylphenol • Sodium Sulfite • Pentaerythritol • Pentachlorophenol • Sodium Pentachlorophenate • Sulfuric Acid • Methanol

National NADONE®

CYCLOHEXANONE

the highest quality you can get in any quantity you can use!

The highest-quality, volume-production Cyclohexanone offered . . . that's still the seven word story of NADONE. *Minimum* purity is now 99.7% but individual shipments regularly better this high standard.

Our Hopewell, Va. plant employs an advanced direct continuous process developed by National Aniline research. It is integrated back to basic raw materials within the Allied Chemical group and well located to serve the resin, plastics, coatings and chemical industries. Drum stocks also available in principal cities.

Have you investigated the benefits of using this high-power solvent to improve your solvent system? In terms of its performance ability, it is attractively priced for many specialized uses.

SEND FOR TECHNICAL BULLETIN I-19

We'll be glad to send you a working sample, price quotation and our 24-page Technical Bulletin #1-19.

NATIONAL ANILINE DIVISION

40 RECTOR STREET, NEW YORK 6, N. Y.

Atlanta Boston Charlotte Chicago Greensboro Los Angeles
Philadelphia Portland, Ore. Providence San Francisco

Allied Chemical